Paducah Site

Annual Site Environmental Report for Calendar Year 2000

Fractions and Multiples of Units

Multiple	Decimal equivalent	Prefix	Symbol	Engineering Format
10^{6}	1,000,000	mega-	M	E+06
10^{3}	1,000	kilo-	k	E+03
10^{2}	100	hecto-	h	E+02
10	10	deka-	da	E+01
10^{-1}	0.1	deci-	d	E-01
10^{-2}	0.01	centi-	c	E-02
10^{-3}	0.001	milli-	m	E-03
10^{-6}	0.000001	micro-	µ	E-06
10^{-9}	0.000000001	nano-	n	E-09
10^{-12}	0.000000000001	pico-	p	E-12
10^{-15}	0.000000000000001	femto-	f	E-15
10^{-18}	0.000000000000000001	atto-	a	E-18

This report is intended to fulfill the requirements of U. S. Department of Energy (DOE) Order DOE O 231.1 Chg 2. The data and information contained in this report were collected in accordance with the Paducah Site Environmental Monitoring Plan (BJC 2000b) approved by DOE. This report is not intended to provide the results of all sampling conducted at the Paducah Site. Additional data collected for other site purposes, such as environmental restoration remedial investigation reports and waste management characterization sampling, are presented in other documents that have been prepared in accordance with applicable DOE guidance and/or laws.

Cover Photo: “Wild Roses” by Tate Graham, May 2001

BJC/PAD - 237

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October 2001

Prepared for Bechtel Jacobs Company LLC
and the U.S. Department of Energy
under Subcontract No. 23900-SC-RM056

by

CDM Federal Services, Inc.
325 Kentucky Avenue
Kevil, Kentucky 42053

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Acronyms and Abbreviations

ACO	Administrative Consent Order
AIP	KDEP Agreement in Principle
AOC	area of concern
ASER	Annual Site Environmental Report
ASTM	American Society of Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BBK	Bayou Creek sample location
Bq	becquerel
BGS	below ground surface
BJC	Bechtel Jacobs Company LLC
BMP	Biological Monitoring Program
BOD	biological oxygen demand
BWMA	Ballard Wildlife Management Area
°C	degrees centigrade
CAA	Clean Air Act
CEDE	committed effective dose equivalent
cm	centimeter
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	Curies
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
CSOU	comprehensive site-wide operable unit
CSTP	Conceptual Site Treatment Plan
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year

D&D	decontamination and decommissioning
DCG	derived concentration guide
DMR	Discharge Monitoring Report
DMSA	DOE Material Storage Area
DNAPL	dense nonaqueous phase liquid
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
DOD	U. S. Department of Defense
DOJ	U.S. Department of Justice
DQO	data quality objective
DSTP	Draft Site Treatment Plan
DUF_6	depleted uranium hexafluoride
DWS	drinking water standards
EA	environmental assessment
EDE	effective dose equivalent
EDD	Electronic Data Deliverable
EDTA	ethylenediaminetetraacetic acid
EIC	DOE Environmental Information Center
EIMS	environmental information management system
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
EPT	Ephemeroptera, Plecoptra, and Trichoptera
ESD	Environmental Sciences Division
ESS	Environmental Services Subcontractor
ETTP	East Tennessee Technology Park
°F	degrees Fahrenheit
FFA	federal facilities agreement
FFC Act	Federal Facilities Compliance Act
FFCA	federal facilities compliance agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact

FS	feasibility study
ft	foot (feet)
g	grams
gy	gray
ha	hectare(s)
HAP	hazardous air pollutant
HEPA	high efficiency particulate air
HF	hydrofluoric acid
hr	hour(s)
HSWA	Hazardous and Solid Waste Amendments
ICRP	International Commission on Radiological Protection
IRA	interim remedial action
KAR	Kentucky Administrative Regulation
KCHS	Kentucky Cabinet for Health and Safety
KDAQ	Kentucky Division for Air Quality
KDEP	Kentucky Department for Environmental Protection
KDFWR	Kentucky Department for Fish and Wildlife Resources
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
kg	kilogram(s)
km	kilometer(s)
KOW	Kentucky Ordnance Works
KPDES	Kentucky Pollutant Discharge Elimination System
KRS	Kentucky Revised Statute
L	liter(s)
lb	pound(s)
LC_{50}	lethal concentration 50%
LMES	Lockheed Martin Energy Systems, Inc.

LRGA	lower portion of the RGA
LUK	Little Bayou Creek sample location
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MACT	Maximum Achievable Control Technology
MAK	Massac Creek sample location
MCL	maximum contaminant level
µCi	microCurie
µg	microgram
mg/L	milligrams
ml	milliliter(s)
mm	millimeter(s)
mR	milliRoentgen(s)
mrem	millirem(s)
MSDS	material safety data sheet
mSv	milliSievert(s)
mt	metric ton(s)
MW	monitoring well
NMIC	National Board Inspection Code
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NOV	notice of violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OREIS	Oak Ridge Environmental Information System
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl

pCi	picoCurie(s)
PEMS	Project Environmental Measurement Systems
pg	picogram(s)
PGDP	Paducah Gaseous Diffusion Plant
pH	hydrogen-ion concentration
PHA	public health assessment
POE	point of exposure
ppb	parts per billion
ppm	parts per million
PP/WM	Pollution Prevention/Waste Minimization
PSTP	Proposed Site Treatment Plan
PTZ	permeable treatment zone
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RD&D	Research, Development, and Demonstration
RFI	RCRA facility investigation
RGA	Regional Gravel Aquifer
RI	remedial investigation
Rn	radon
ROD	Record of Decision
SE	site evaluation
SHPO	State Historic Preservation Officer
SMO	Sample Management Office
SMP	Site Management Plan
SO_2	sulfur dioxide
SOP	Standard Operating Procedure
SOW	statement of work
SS	sediment sample location
SSAB	Site Specific Advisory Board
Sv	sievert

SVOA	semivolatile organic
SW	surface-water sample location
SWMU	solid waste management unit
^{99}Tc	technetium-99
TCE	trichloroethylene (also called trichloroethene)
TCLP	Toxicity Characteristic Leaching Procedure
TLD	thermoluminescent dosimeter
TRE	toxicity reduction evaluation
TRU	transuranic element
TSCA	Toxic Substances Control Act
TUa	acute toxicity unit
TUc	chronic toxicity unit
UCRS	Upper Continental Recharge System
UE	uranium enrichment
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
UO_3	uranium trioxide
URGA	upper portion of the RGA
USEC	United States Enrichment Corporation
UST	underground storage tank
VOC	volatile organic compound
WAG	waste area group
WKWMA	West Kentucky Wildlife Management Area

Request for Comments

The U. S. Department of Energy (DOE) requires an annual site environmental report from each of the sites operating under its authority. These reports present the results from the various environmental monitoring programs and activities carried out during the year. This *Paducah Site Annual Site Environmental Report for Calendar Year 2000* was prepared to fulfill DOE requirements. This report is a public document, distributed to government regulators, business persons, special interest groups, and members of the public at large.

This report is based on thousands of environmental samples collected at or near the Paducah Site. Significant efforts were made to provide the data collected and details of the site environmental management programs in a clear and concise manner, while presenting summary information. The editors of this report encourage comments in order to beter address the needs of our readers in future site environmental reports. Please send your comments to the following address:

Paducah Site Office

U. S. Department of Energy

P. O. Box 1410

Paducah, Kentucky 42002

1 Site Operation and Overview

Abstract

The Paducah Gaseous Diffusion Plant (PGDP), located in McCracken County, Kentucky, has been producing enriched uranium since 1952. In July 1993, the U.S. Department of Energy (DOE) leased the production areas of the site to the United States Enrichment Corporation (USEC). Responsibility for the environmental restoration, legacy waste management, and uranium hexafluoride (UF_6) cylinder management programs is maintained by DOE. DOE also oversees an environmental monitoring and management program to ensure protection of human health and the environment and compliance with all applicable regulatory requirements. This document summarizes calendar year (CY) 2000 environmental management activities, including effluent monitoring, environmental surveillance, and environmental compliance status. It also highlights significant site program efforts conducted by DOE and its contractors and subcontractors at the Paducah Site. ***This report does not include USEC environmental activities.***

Introduction

DOE requires that environmental monitoring be conducted and documented for all of its facilities under the purview of DOE Order DOE O 231.1 Chg 2, *Environment, Safety and Health Reporting* (DOE 1996a). Several other laws, regulations, and DOE directives require minimum environmental compliance standards. The purpose of this document is to summarize CY 2000 environmental management activities, including effluent monitoring, environmental surveillance, and environmental compliance status, and to highlight significant site program efforts. Since April 1, 1998, Paducah Site programs have been coordinated by DOE's managing and integrating contractor, Bechtel Jacobs Company LLC (BJC). References in this report to the Paducah Site generally mean the property, programs, and facilities at or near the PGDP for which DOE has ultimate responsibility.

Environmental monitoring consists of the following two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the direct measurement, or the collection and analysis of samples, and of liquid and gaseous discharges to the environment. Environmental surveillance is the direct measurement, or the collection and analysis of samples consisting of air, water, soil, biota, and other media. Environmental monitoring is performed to characterize and quantify contaminants, assess radiation exposure, demonstrate compliance with applicable standards and permit requirements, and detect and assess the effects (if any) on the local population and environment. Multiple samples are collected throughout the year and are analyzed for radioactivity, chemical content, and various physical attributes.

The overall goal for environmental management is to protect site personnel, the

environment, and the Paducah Site's neighbors, and to maintain full compliance with all current environmental regulations. The current environmental strategy is to prevent deficiencies, to identify any deficiencies, and to develop a system to resolve them. The long-range goal of environmental management is to reduce exposures of the public, workers, and biota to harmful chemicals and radiation.

Background

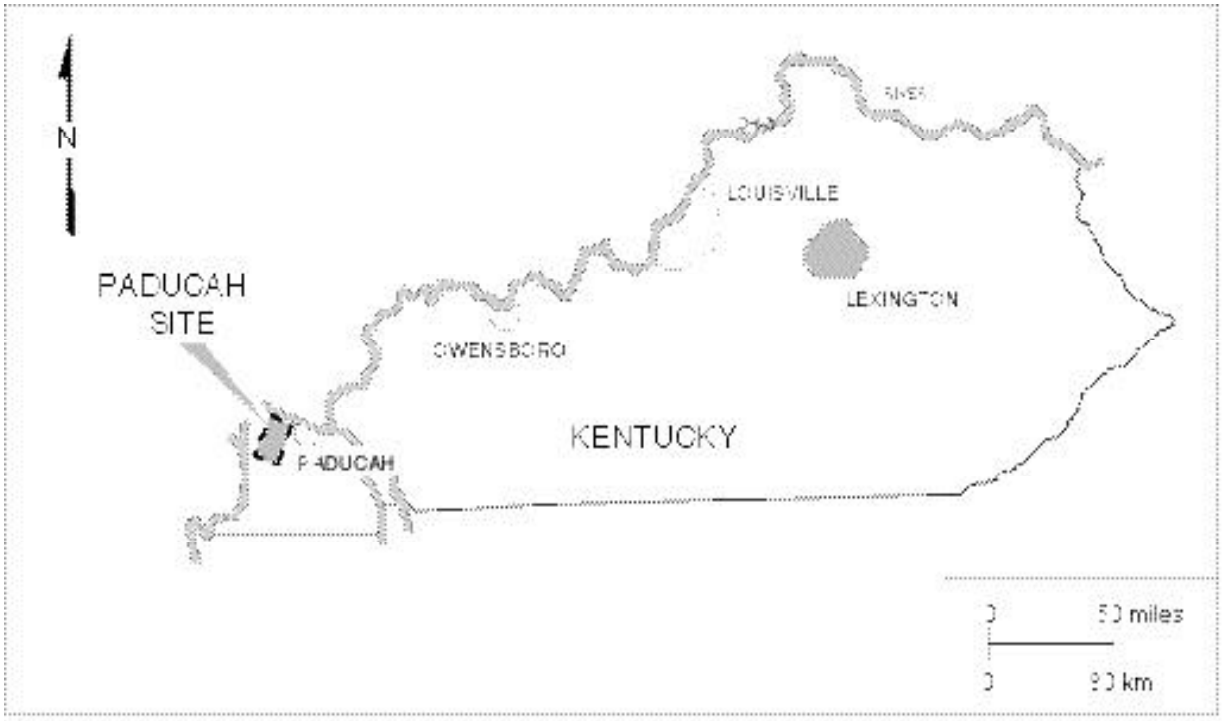
Before World War II, the area now occupied by the PGDP was used for agricultural purposes. Numerous small farms produced various grain crops and provided pasture for livestock. Early in the war, a 6526-hectare (ha) (16,126-acre) tract was assembled for construction of the Kentucky Ordnance Works (KOW), which was subsequently operated by the Atlas Powder Company until the end of the war. At that time it was turned over to the Federal Farm Mortgage Corporation, and then to the General Services Administration.

In 1950, the U. S. Department of Defense (DOD) and DOE's predecessor, the Atomic Energy Commission, began efforts to expand fissionable material production capacity. As part of this effort, the National Security Resources Board was instructed to designate power areas within a strategically safe area of the United States. Eight government-owned sites were initially selected as candidate areas, one of which was the KOW site. In October 1950, as a result of joint recommendations from the DOD, Department of State, and the Atomic Energy Commission, President Truman directed the Atomic Energy Commission to further expand production of atomic weapons. One of the principal facets of this expansion program was the provision for a new gaseous diffusion plant. On October 18, 1950, the Atomic Energy Commission approved the Paducah Site for uranium enrichment operations and formally requested the Department of the Army to transfer the site from the General Services Administration to the Atomic Energy Commission.

Although construction of PGDP was not completed until 1954, production of enriched uranium began in 1952. The plant's mission, uranium enrichment, has continued unchanged and the original facilities are still in operation, albeit with substantial upgrading and refurbishment. Of the 3062 ha (7566 acres) acquired by the Atomic Energy Commission, 551 ha (1361 acres) were subsequently transferred to the Tennessee Valley Authority (Shawnee Steam Plant site) and 1125 ha (2781 acres) were conveyed to the commonwealth of Kentucky for use in wildlife conservation and for recreational purposes [West Kentucky Wildlife Management Area (WKWMA)]. DOE's current holdings at the Paducah Site total 1439 ha (3556 acres).

At Paducah's uranium enrichment plant, recycled uranium from nuclear reactors was introduced into the PGDP enrichment "cascade" in 1953 and continued through 1964. In 1964, cascade feed material was switched solely to virgin-mined uranium. Use of recycled uranium was resumed in 1969 and continued through 1976. In 1976, the practice of recycling uranium feed material from nuclear reactors was halted and never resumed. During the recycling time periods, Paducah received approximately 100,000 tons (90,000 metric tons) of recycled uranium containing an estimated 328 grams of plutonium-239 (^{239}Pu), 18,400 grams of neptunium-237 (^{237}Np), and 661,000 grams of technetium-99 (^{99}Tc). The majority of the ^{239}Pu and ^{237}Np was separated out as waste during the initial chemical conversion to UF_6. Concentrations of transuranics (e.g., ^{239}Pu and ^{237}Np) and ^{99}Tc are believed to have been deposited on internal surfaces of process equipment, with concentrations also being deposited in waste products.

In October 1992, congressional passage of the National Energy Policy Act established USEC. Effective July 1, 1993, DOE leased the plant production operations facilities to USEC. Under the terms of the lease, USEC assumed responsibility for environmental compliance activities directly associated with uranium enrichment operations.



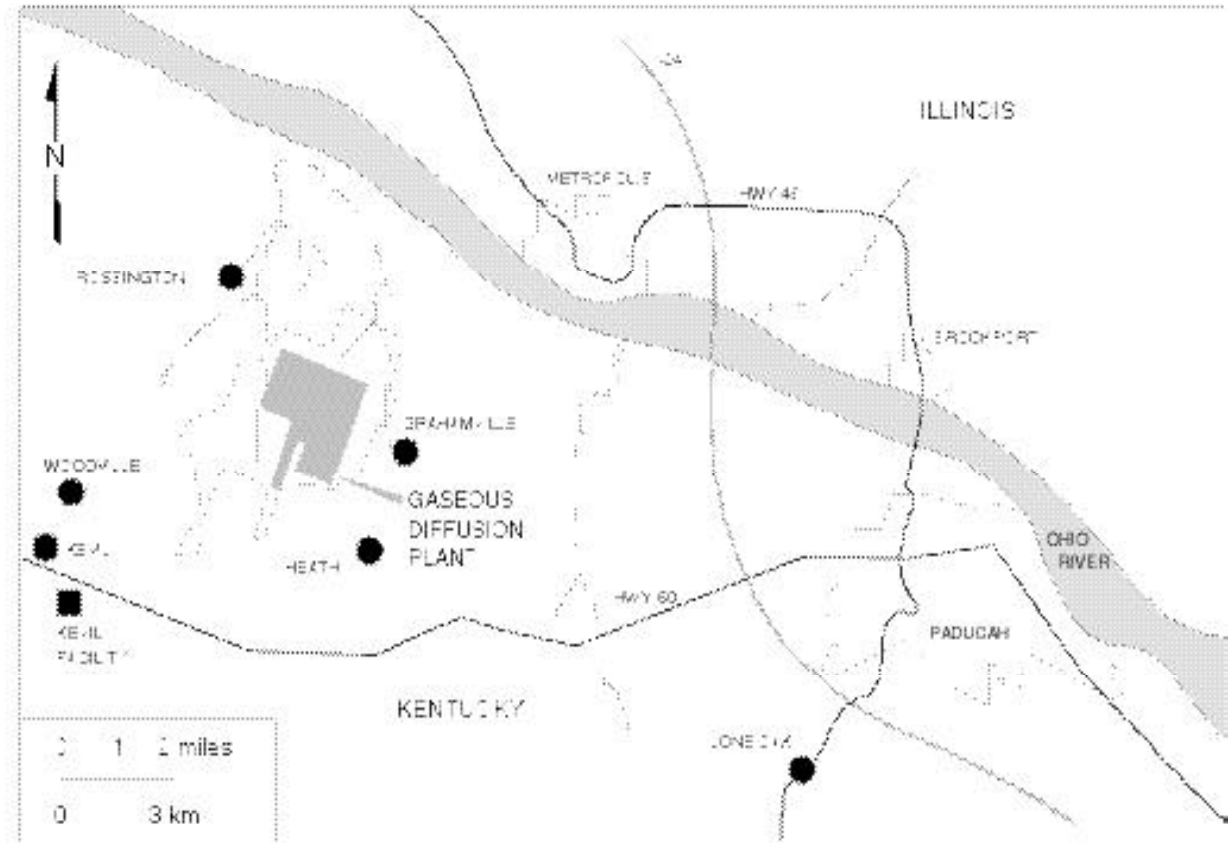


Figure 1.1 Location of the Paducah Site.

Under the lease agreement with USEC, DOE retained responsibility for the site Environmental Restoration Program; the Enrichment Facilities Program; and the legacy Waste Management Program, including all waste inventories predating July 1, 1993, and wastes generated by current DOE activities. DOE is responsible for Kentucky Pollutant Discharge Elimination System (KPDES) compliance at outfalls not leased to USEC. DOE has also retained manager and cooperator status of facilities not leased to USEC. DOE and USEC have negotiated the lease of specific plant site facilities, written memoranda of agreement to define their respective roles and responsibilities under the lease, and developed organizations and budgets to support their respective functions. DOE is the owner and operator for Resource Conservation and Recovery Act (RCRA) permitted facilities and is responsible for compliance with the RCRA permit.

Description of Site Locale

Location

The Paducah Site is located in a generally rural area of McCracken County, Kentucky. The center of PGDP is about 16 kilometers (km) (10 miles) west of Paducah, Kentucky, and 5 km (3 miles) south of the Ohio River (Figure 1.1). The industrial portion of the PGDP is situated within a fenced security area and constitutes about 303 ha (748 acres). Within this area, which is designated as secured industrial land use, are numerous active and inactive production buildings, offices, equipment and material storage areas, active and inactive waste management units, and other support facilities (Figure 1.1). The remaining 1083 ha (2675 acres) of DOE-owned land at the Paducah Site is comprised of approximately 279 ha (689 acres) of "buffer zone" designated as unsecured industrial, and 1131 ha (1986 acres) licensed to the commonwealth of Kentucky as part of the 2793-ha (6900-acre) WKWMA. There are no residences on DOE property at the Paducah Site. DOE has also acquired approximately 133 acres in easements.

The following three small communities are located within 5 km (3 miles) of the DOE property boundary at PGDP: Heath and Grahamville to the east, and Kevil to the southwest. The closest commercial airport is Barkley Field approximately 8 km (5 miles) to the southeast. The population within an 80-km (50-mile) radius of PGDP is about 500,000, of which about 66,000 residents are located within a 16-km (10-mile) radius (DOC 1994).

Climate

The Paducah Site is located in the humid continental zone where summers are warm [July averages 26°C (79°F)] and winters are moderately cold [January averages 1.7°C (35°F)]. Yearly precipitation averages about 125 centimeters (49 inches). The prevailing wind is from the south-southwest at approximately 16 km (10 miles) per hour.

Surface Water Drainage

The Paducah Site is situated in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is about 24 km (15 miles) upstream of the site, and the confluence of the Ohio River with the Mississippi River is about 56 km (35 miles) downstream. The plant is located on a local drainage divide; surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Bayou Creek [commonly referred to as "Big Bayou Creek" in previous Annual Site Environmental Reports (ASERs)]. Bayou Creek is a perennial stream that flows toward the Ohio River along a 14-km (9-mile) course. Little Bayou Creek is an intermittent stream that flows north toward the Ohio River along a 11-km (7-mile) course. The two creeks converge 5 km (3 miles) north of the plant before emptying into the Ohio River.

Flooding in the area is associated with Bayou and Little Bayou creeks and the Ohio River. Maps of the 100-year flood elevations calculated show that all three have 100-year floodplains within the

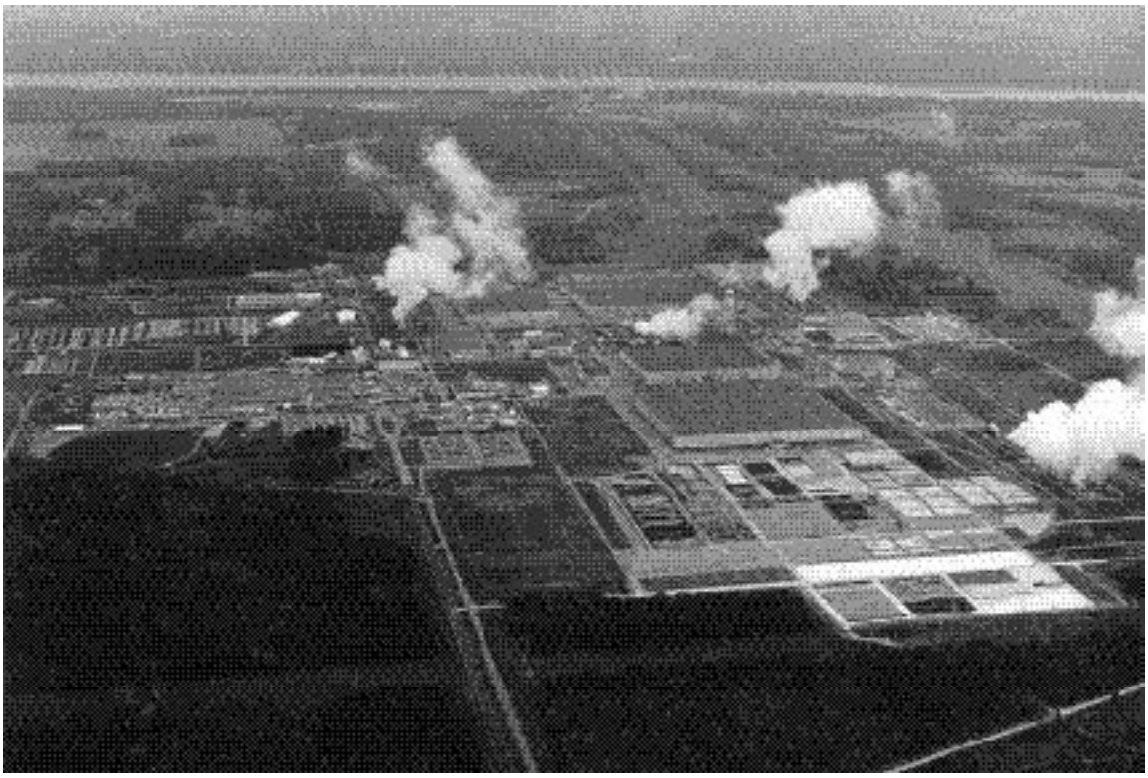


Figure 1.2 The Paducah Gaseous Diffusion Plant

DOE boundary at PGDP ranging from approximately 340 to 380 feet above mean sea level. Plant elevations renage from about 370 to 385 feet above mean sea level. (COE 1994).

Wetlands

More than 1100 separate wetlands, totaling over 648 ha (1600 acres), were found in a study area of about 4860 ha (12,000 acres) in and around the Paducah Site (COE 1994 and CDM 1994). These wetlands have been classified into 16 cover types. More than 60% of the total wetland area is forested.

Soils and Hydrogeology

Soils of the area are predominantly silt loams that are poorly drained, acidic, and have little organic content. Of the six primary soil types associated with the Paducah Site, five commonly have the characteristics necessary to be considered prime farmland by the Natural Resources Conservation Service, formerly the Soil Conservation Service (Humphrey 1976).

The local groundwater flow system at the Paducah Site contains the following four major components (listed from shallowest to deepest): (1) the terrace gravels, (2) the Upper Continental Recharge System (UCRS), (3) the Regional Gravel Aquifer (RGA), and (4) the McNairy flow system. The terrace gravels consist of shallow Pliocene gravel deposits in the southern portion of the plant site. These deposits usually lack sufficient

thickness and saturation to constitute an aquifer, but may be an important source of groundwater recharge to the RGA.

The UCRS consists mainly of clay silt with interbedded sand and gravel in the upper continental deposits. The system is so named because of its characteristic recharge to the RGA.

The RGA consists of sand and gravel facies in the lower continental deposits, gravel and coarse sand portions of the upper McNairy that are directly adjacent to the lower continental deposits, coarse-grained sediments at the base of the upper continental deposits, and alluvium adjacent to the Ohio River. These deposits have an average thickness of 9 m (30 ft) and can be more than 21 m (70 ft) thick along an axis that trends east-west through the site. The RGA is the uppermost and primary aquifer, formerly used by private residences north of the Paducah Site.

The McNairy flow system consists of interbedded and interlensing sand, silt, and clay of the McNairy Formation. Sand facies account for 40 to 50% of the total formation thickness of approximately 69 m (225 ft).

Groundwater flow originates south of the Paducah Site within Eocene sands and the terrace gravels. Groundwater within the terrace gravels either discharges to local streams or recharges the RGA, although the flow regime of the terrace gravels is not fully understood. Groundwater flow through the UCRS is ultimately downward, also recharging the RGA. From the plant site, groundwater flows generally northward in the RGA toward the Ohio River, which is the local base level for the system.

Ecological Resources

Vegetation

Much of the Paducah Site has been impacted by human activity. Vegetation communities on the reservation are indicative of old field succession (e.g., grassy fields, field scrub-shrub, and upland mixed hardwoods).

The open grassland areas, most of which are managed by WKWMA personnel, are periodically mowed or burned to maintain early successional vegetation, which is dominated by members of the Compositae family and various grasses. Management practices on the WKWMA encourage reestablishment of once common native grasses such as eastern gama grass and Indian grass. Other species commonly cultivated for wildlife forage are corn, millet, milo, and soybean (CH2M Hill 1992a).

Field scrub-shrub communities consist of sun-tolerant wooded species such as persimmon, maples, black locust, sumac, and oaks (CH2M Hill 1991a). The undergrowth may vary depending on the location of the woodlands. Wooded areas near maintained grasslands may have an undergrowth dominated by grasses; other communities may contain a thick undergrowth of shrubs, including sumac, pokeweed, honeysuckle, blackberry, and grape.

Upland mixed hardwoods contain a variety of upland and transitional species. Dominant species include oaks, shagbark and shellbark hickory, and sugarberry (CH2M Hill 1991a). Undergrowth may vary from open, with limited vegetation for more mature stands of trees, to dense undergrowth similar to that described for a scrub-shrub community.

Wildlife

Wildlife species indigenous to hardwood forests, scrub-shrub, and open grassland communities are present at the Paducah Site. Grassy fields are frequented by rabbits, mice, songbirds, and a variety of other small mammals and birds. Redwing blackbirds, killdeer, cardinals, mourning doves, bobwhite quail, meadowlarks, warblers, sparrows, and red-tailed hawks have been observed in such areas. Scrub-shrub

communities support a variety of wildlife including opossums, voles, moles, raccoons, gray squirrels, killdeer, bluejays, redwing blackbirds, bluebirds, cardinals, mourning doves, shrike, warblers, turkeys, and meadowlarks. Deer, squirrels, raccoons, turkeys, songbirds, and great horned owls are found within the mature woodlands of the DOE reservation (CH2M Hill 1991a). In addition, the Ohio River serves as a major flyway for migratory birds, which are occasionally seen on the Paducah Site (DOE 1995).

Amphibians and reptiles are common throughout the Paducah Site. Amphibians likely to inhabit the area include the American and Woodhouse's toads. Reptiles include the eastern box turtle and several species of snakes. Also, fish populations in Bayou and Little Bayou creeks are numerically dominated by various species of sunfish (DOE 1995).

Threatened and Endangered Species

A threatened and endangered species investigation identified federally listed, proposed, or candidate species potentially occurring at or near the Paducah Site (COE 1994). Updated information is obtained on a regular basis from federal and state sources. Currently, potential habitat for nine species of federal concern exists in the study area (Section 2, Table 2.2). Six of these species are listed as endangered under the Endangered Species Act of 1973, one is listed as threatened, and two are candidate species that may later be proposed for listing. All are animal species, eight of which are associated with the Ohio River. Of note, significant potential summer habitat exists at the Paducah Site for the Indiana bat, a federally listed endangered species. However, no federally listed or candidate species have been found on DOE property at the Paducah Site. Also, no property at the Paducah Site has been designated as critical habitat in accordance with the Endangered Species Act of 1973.

Cultural Resources

In a study area of about 4860 ha (12,000 acres) in and around the Paducah Site, there are 35 sites of cultural significance recorded with the State Historic Preservation Officer (SHPO) and several more unrecorded sites (COE 1994). Most of these sites are prehistoric and located in the Ohio River floodplain. Six of the sites are on DOE property at PGDP. None of the sites are included in, or have been nominated to, the National Register of Historic Places, although some are potentially eligible. Further assessment is needed in regard to the historical significance of PGDP facilities.

Site Program Missions

The following three major programs are operated by the DOE at the Paducah Site: (1) Environmental Restoration, (2) Waste Management, and (3) Enrichment Facilities. The mission of the Environmental Restoration Program is to ensure that releases from past operations and waste management at the Paducah Site are investigated and that appropriate remedial action is taken for protection of human health and the environment in accordance with the Federal Facilities Agreement (FFA) (DOE 1998). The mission of the Waste Management Program is to characterize and dispose of the legacy waste stored on-site in compliance with various federal facilities compliance agreements (FFCAs). The primary mission of the Enrichment Facilities Program is to maintain safe, compliant storage of the DOE depleted UF_6 inventory, pending final disposition of the material, and to manage facilities and grounds not leased to USEC. The environmental monitoring summarized in this report supports all three programs.

2 Environmental Compliance

Abstract

The policy of DOE and its contractors and subcontractors at the Paducah Site is to conduct operations safely and minimize the impact of operations on the environment. Protection of the public, environment, and employees is considered a responsibility of paramount importance. The Paducah Site maintains an environmental compliance program aimed at meeting all applicable requirements and minimizing impacts.

Introduction

Local, state, and federal agencies, including DOE, are responsible for enforcing environmental regulations at the Paducah Site. Principal regulating agencies are the U.S. Environmental Protection Agency (EPA) Region IV and the Kentucky Department for Environmental Protection (KDEP). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable laws and regulations.

The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In some instances, the EPA has delegated regulatory authority to KDEP when the Kentucky program meets or exceeds EPA requirements. Where regulatory authority is not delegated, EPA Region IV is responsible for reviewing and evaluating compliance with EPA regulations as they pertain to the Paducah Site. Table 2.1 provides a summary of the Paducah Site environmental permits maintained by DOE in 2000.

The following is a list of the major environmental laws and requirements applicable to the Paducah Site. Each is discussed in this section.

- Resource Conservation and Recovery Act ;
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA);
- Federal Facilities Compliance (FFC) Act;
- Toxicity Characteristic Leaching Procedure (TCLP) FFCA;
- National Environmental Policy Act (NEPA);
- National Historic Preservation Act (NHPA);
- Endangered Species Act;

Table 2.1 Environmental permit summary

Permit Type	Issued By	Expiration Date	Permit Number	Issued To
	Water			
KPDES	KDOW	3/31/2003	KY0004049	DOE
Stormwater Point Sources	KDOW	9 /30/2002	KYR100000	DOE
	Solid Waste			
Residential Landfill (closed)	KDWM	11/1/2003)	073-00014	DOE
Inert Landfill (closed)	KDWM	6/11/2003	073-00015	DOE
Solid Waste Contained Landfill (construction/operation)	KDWM	11/4/2006	073-00045	DOE
	RCRA			
State Hazardous Waste Management Permit	KDWM	8/19/2001	KY8890008982	DOE/BJC
EPA Hazardous & Solid Waste Amendments Permit	EPA	8/19/2001	KY8890008982	DOE/BJC
	Air			
Cylinder Refurbishment	KDAQ	6/10/2003	S-98-044	DOE
Vortec	KDAQ	7/15/2001	S-96-239	DOE

NA = Not Applicable
KDOW = Kentucky Division of Water
KDWM = Kentucky Division of Waste Management
KDAQ = Kentucky Division of Air Quality

- Executive Order 11988, "Floodplain Management";
- Executive Order 11990, "Protection of Wetlands";
- Farmland Protection Policy Act;
- Clean Water Act (CWA);
- Toxic Substances Control Act (TSCA);
- Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA);
- Emergency Planning and Community Right-to-Know Act (EPCRA);
- Clean Air Act (CAA); and
- Atomic Energy Act.

Compliance Activities

Resource Conservation and Recovery Act

Regulatory standards for the identification, treatment, storage, and disposal of hazardous waste are established by RCRA. Waste generators must follow specific requirements outlined in RCRA regulations for handling hazardous wastes. Owners and operators of hazardous waste treatment, storage, and disposal facilities are required to obtain operating and closure permits for hazardous waste treatment, storage, and disposal activities. Paducah generates both hazardous waste and mixed waste (i.e., hazardous waste mixed with radionuclides) and operates four permitted hazardous waste storage and treatment facilities.

Resource Conservation and Recovery Act Permit

Part A and Part B permit applications of RCRA for storage and treatment of hazardous wastes were initially submitted for the Paducah Site in the late 1980s. At that time, the EPA had

authorized the commonwealth of Kentucky to exclusively administer the RCRA-base program for treatment, storage, and disposal units, but had not given the authorization to administer the 1984 Hazardous and Solid Waste Amendments (HSWA) provisions. Therefore, a permit application was submitted to the EPA and the Kentucky Division of Waste Management (KDWM) for treatment and storage of hazardous wastes.

On July 16, 1991, a 10-year RCRA permit (No. KY8890008982) was issued by KDWM and EPA to DOE as owner and operator and DOE's prime contractor (currently BJC) as cooperator. This RCRA permit consists of the following two individual permits: (1) a hazardous waste management permit administered by the Commonwealth of Kentucky and (2) a HSWA permit administered by the EPA. The hazardous waste management permit contains regulatory provisions for treatment, storage, and disposal activities at PGDP, authorized under the RCRA-base program (pre-HSWA), as well as HSWA provisions. The HSWA permit addresses only the provisions of the HSWA, which include corrective actions for solid waste management units (SWMUs), air emissions, and the land disposal restrictions. In 1996, Kentucky received authorization to administer the HSWA provisions in lieu of EPA. Even though the state is authorized, the EPA's portion of the RCRA permit will remain in effect until it expires August 19, 2001, or is rescinded. Therefore, the Paducah Site still has dual requirements for corrective actions under state and federal authority.

As part of the corrective action requirements, the RCRA permit's schedule of compliance requires DOE to develop and implement a RCRA facility investigation (RFI) work plan for SWMUs and areas of concern (AOCs). DOE has submitted RFI work plans to the EPA and the KDWM in accordance with the time frames specified in the schedule of compliance. These RFI work plans are described in further detail in the section on CERCLA activities.

Modifications to the Resource Conservation and Recovery Act Permit

Since issuance of the KDWM Hazardous Waste Management portion of the RCRA permit in 1991, 15 permit modifications have been approved. Modification 15 was approved in 1999. This major modification allows the Paducah Site to perform treatment in containers utilizing neutralization, oxidation/reduction, and stabilization techniques. There were no modifications to this permit in 2000.

Resource Conservation and Recovery Act Closure Activities

No RCRA closure activities occurred in 2000.

Resource Conservation and Recovery Act Notices of Violation

DOE received four notices of violations (NOVs) during 2000 from the KDWM. The first NOV was dated January 14, 2000, based upon a November 4, 1999, inspection by KDWM personnel of silt fences around the scrapyards (SWMUs 12, 14, and 15). The silt fences were identified to be deteriorated at numerous locations and no longer effective in filtering sediments from the scrapyard surfacewater runoff. Drain pipes crossing the northern fence boundary were also observed. The drains are not shown in the as-built drawings contained in the Interim Measures Report and Operation and Maintenance Plan for containment of scrapyard runoff. The NOV stated that the silt fences were not maintained in accordance with conditions III.E.5 and III.E.6 of the Paducah HSWA permit. A work plan to address maintenance of existing erosion and sedimentation controls, and installation of new controls, was approved by KDWM and implemented by DOE in 2000 (DOE 2000f).

An NOV dated May 23, 2000, was received from KDWM on May 26, for "Failure to Comply with Permit Condition II.J.9.a of the Paducah RCRA Permit." Specifically, two analytical

paramteters (99Tc and uranium) were not analyzed in the C-404 Groundwater Monitoring Well samples collected in July 1998, January 1999, July 1999, and January 2000. This oversight was identified in early May 2000 by site personnel and reported to KDWM in correspondence dated May 4, 2000. ^{99}Tc and uranium have been added to the parameters to be monitored.

On August 9, 2000, KDWM issued an NOV dated August 8, 2000, that alleges DOE violated its hazardous waste permit and state regulation [Part II.I.5 of the hazardous waste management permit and 401 Kentucky Administrative Regulation (KAR) 34:80] by "failing to separate containers of hazardous waste from incompatible materials by a dike, berm, wall, or other device." This NOV was a result of an inspection conducted July 27, 2000. A state inspector noted that a high-density polyethylene drum of hydrofluoric acid (HF) was stored on a metal pallet in a diked area of the C-752-A RCRA storage facility. This pallet was considered incompatible with the HF, since HF may generate explosive hydrogen gas when in contact with metals. The pallet was covered with 6-mil polyethylene plastic sheeting, but the plastic sheeting on the pallet did not extend over the edge of the dike. If the drum had leaked, HF could have reached the metal pallet. Verbal notification of the concern was received on July 31, 2000. Immediate corrective action was taken. The drum was lifted off the pallet and a larger piece of polyethylene plastic was placed between the pallet and the drum, extending over the dike.

An NOV from KDWM dated September 5, 2000, was received by DOE September 7, alleging that DOE generated solid wastes as defined in 401 KAR Chapter 31 and that DOE failed to characterize these wastes in violation of Kentucky Revised Statute (KRS) 222.46-520 and 401 KAR 32:030, Section 2. These wastes have subsequently been managed in approximately 160 units referred to as DOE Material Storage Areas (DMSAs). Actions taken in response to this NOV included submittal of a Corrective Action Plan for characterizing waste and materials in these DMSAs and identifying the DMSAs as SMWUs.

Land Disposal Restrictions

Hazardous waste is subject to land disposal restrictions storage prohibitions which permits storage only for accumulation of sufficient quantities of hazardous waste to facilitate proper treatment, recycling, or disposal. Hazardous wastes are not to be stored for more than one year. The Paducah Site generates mostly mixed waste, which is a combination of hazardous waste and radioactive waste. Nationally, there are very limited opportunities for treatment and disposal of mixed waste. Therefore, the Paducah Site stores most of the mixed waste that is generated for longer than one year. Storage of waste for this purpose (lack of treatment and disposal options) does not comply with land disposal restriction regulations. If not for the radioactive constituents, this waste would not pose a compliance problem for the site, as there would be treatment and disposal options readily available. Consequently, on June 30, 1992, DOE entered into an FFCA with EPA Region IV to regulate the treatment and storage of land disposal restriction mixed waste at the Paducah Site. On April 13, 1998, EPA Region IV released DOE from the FFCA, and allowed KDWM to regulate mixed waste under the FFC Act.

Federal Facilities Compliance Act

The FFC Act was enacted in October 1992. This act waived the immunity from fines and penalties that had existed for federal facilities for violations of hazardous waste management as defined by RCRA. As a result of the complex issues and problems associated with mixed chemical hazardous and radioactive waste (mixed waste) as well as the lack of treatment and disposal capacity, the FFC Act allowed a three-year extension for DOE facilities to prepare schedules and plans. These addressed how the facilities would manage their mixed waste in compliance with applicable RCRA regulations. The three-year waiver can be extended under the following conditions: (1) a mixed waste treatment plan and compliance schedule are approved by the appropriate agency, (2) an implementing order with that agency is signed, and (3) adherence to the plan and implementing order are maintained by the facility.

To facilitate compliance with the FFC Act and address the myriad of complex issues involved, the Paducah Site, along with 48 other DOE sites, began a four-phase approach. The first phase consisted of gathering required information and submitting to the EPA and state agencies an inventory of mixed wastes (mixed waste inventory report), including information pertaining to characterization and waste generation volumes.

The second phase of the approach involved the development of a Conceptual Site Treatment Plan (CSTP). The plan included investigation of the existing treatment capacity for facility wastes and, where there was no existing capacity, procurement of information on potential treatment technologies or options that could be employed to meet operation requirements. The Paducah Site submitted the CSTP in October 1993.

The third phase of the approach expanded on the information in the CSTP to identify treatment options that are preferred both environmentally and economically. The information gathered by the ongoing waste characterization program and the technology evaluation and development program outlined in the CSTP formed the basis for the Draft Site Treatment Plan (DSTP), which was submitted to the regulators in August 1994.

The fourth phase of the approach combined the preferred treatment options from the DSTP with regulator and stakeholder comments and the overall DOE complex picture to formulate a Proposed Site Treatment Plan (PSTP). This PSTP was submitted to the regulators March 31, 1995, and provides details on how and where Paducah Site mixed waste is to be treated. On October 3, 1995, KDWM issued a Unilateral Order and the Site Treatment Plan for the Paducah Site. The Paducah Site has complied with the FFC Act and Site Treatment Plan since issuance.

Toxicity Characteristic Leaching Procedure Federal Facility Compliance Agreement

The Paducah Site has generated a significant volume of waste materials that are stored on-site. A large quantity of this waste was generated, characterized, and placed in storage before September 25, 1990. At that time, characterization required utilizing the Extraction Procedure for toxicity. On September 25, 1990, a new regulation became effective replacing the Extraction Procedure for toxicity with the TCLP. Since the accumulated wastes had not been characterized under the new toxicity characteristic regulations, DOE needed revised characterization data for these wastes by the new protocol.

On March 26, 1992, EPA Region IV and DOE entered into a TCLP FFCA concerning the regulatory status of these wastes. The TCLP FFCA requires the Paducah Site to identify those solid wastes that are not being managed in RCRA-regulated units and that have not been characterized under the TCLP test method. Additionally, the FFCA requires the Paducah Site to provide a schedule for TCLP characterization of the identified waste.

In response to the FFCA, the Paducah Site submitted an implementation plan that established a general framework for compliance with the requirements of the FFCA. The implementation plan established priorities for the characterization program and the nature of the data to be collected, and included a schedule for TCLP characterization of the identified waste. The primary characterization objective was the acquisition of sufficient data to safely handle the waste and provide for determination of its status under RCRA. Characterization of the waste with respect to PCB and radionuclide concentrations was the second objective. The final characterization objective was the collection of data related to treatment and/or disposal of the waste.

A three-phase program for accomplishing the goals of the plan was developed. Phase I

activities consisted of data compilation and waste prioritization. Phase II involved identification of discrete waste streams and development of characterization plans. The final phase of the program included the development of sampling and analysis plans, field sampling, and data reporting. All three phases of the program have been completed. Characterization was completed by December 2000.

Solid Waste Management

The Paducah Site disposes of a portion of its solid waste at its on-site contained landfill facility, C-746-U. Construction of the C-746-U Landfill began in 1995 and was completed in 1996. The operation permit was received from KDWM in November 1996. Disposal of waste at the landfill began in February 1997. The C-746-U Landfill operated from February 1997 through October 1999 and disposed of approximately 16,000 tons of solid waste. In November 1999, the landfill suspended waste acceptance activities for all waste streams with the exception of wastes classified as "no rad added." An Environmental Assessment (EA) was initiated by BJC with disposal operations placed on hold until the EA is approved.

Office waste generated by DOE and its contractors (generated at the plant site) is taken off-site for disposal. Off-site disposal of the office waste is provided by Liquid Waste Disposal at Calvert City, Kentucky.

No NOVs were received by DOE that cited violations of solid waste regulations. However, DOE did receive an NOV citing violations of hazardous waste regulations that also involved allegations of failure to characterize solid waste.

Comprehensive Environmental Response, Compensation, and Liability Act

An Administrative Consent Order (ACO) was entered into by DOE and EPA in August 1988 under Section 104and 106 of CERCLA. The ACO was in response to the off-site groundwater contamination detected in July 1988.

On May 31, 1994, the Paducah Site was placed on the EPA National Priorities List (NPL), which is a list of sites across the nation designated by EPA as a high priority for site remediation. The EPA uses the Hazard Ranking System to determine which sites should be included on the NPL. A site is eligible for the NPL if it ranks 28.5 on the system; the Paducah Site ranked 56.9. Being placed on the NPL means DOE must follow the cleanup requirements of CERCLA.

Section 120 of CERCLA requires federal facilities on the NPL to enter into a FFA, also referred to as an interagency agreement, with the appropriate regulatory agencies. The FFA, which was signed February 13, 1998, establishes a process for decision making for remediation of the Paducah Site and coordinates CERCLA remedial action requirements with RCRA corrective action requirements specified in the RCRA permits. Upon signature of the FFA, the parties agreed to terminate the CERCLA ACO because those activities can be continued under the FFA. According to the FFA, DOE is required to submit an annual Site Management Plan (SMP) to EPA and KDEP. The plan summarizes the remediation work completed to date, outlines remedial priorities, and contains schedules for completing future work. The SMP is submitted to the regulators annually in November to update the enforceable milestones and include any new strategic approaches.

The Agency for Toxic Substances and Disease Registry (ATSDR), based in Atlanta, Georgia, is part of the U.S. Public Health Service. As required by CERCLA, the agency conducts public health assessments of hazardous waste sites listed or proposed for listing on the NPL. Representatives from the ATSDR made their initial site visit to Paducah in May 1994 to assign a ranking to the site for priority in scheduling the health assessment. A "B" ranking was assigned to Paducah, which is the second highest priority. The ranking was based on groundwater contamination associated with the plant that had affected

several off-site wells. The ATSDR is aware of the actions the site has taken since 1988 to address the risks from the potential use of this contaminated water.

In 1995, the ATSDR visited the Paducah Site to initiate a public health assessment (PHA). The PHA was scheduled to be issued in September of 2000; however, it has not yet been received.

Comprehensive Environmental Response, Compensation, and Liability Act Reportable Quantities

There were no spills of a CERCLA reportable quantity at the Paducah Site in 2000.

Underground Storage Tanks

Underground storage tank systems (USTs) at the Paducah Site have been used to store petroleum products, such as gasoline, diesel fuel, and waste oil. These USTs are regulated under RCRA Subtitle I [40 Code of Federal Regulations (CFR) Part 280] and Kentucky UST regulations (401 KAR Chapter 42), or are exempt from specific UST regulations.

DOE is responsible for 14 of the 16 site USTs that have been reported to KDWM in accordance with regulatory notification requirements. Of DOE's 14 USTs, none are currently in use. Three have been removed from the ground, eight have been filled in place with inert material, one was abandoned in place, and two were determined not to exist.

At of the end of 2000, only three of DOE's USTs had not met all regulatory requirements necessary to achieve permanent ("clean") closure. Two of these three USTs are exempt from RCRA and Kentucky UST regulations and are being closed in association with the Paducah Site's remediation program. Activities in 2000 included submittal to KDWM of Closure Assessment Reports and correspondence related to the three USTs. Closure activities for USTs continued into 2001.

National Environmental Policy Act

An evaluation of the potential environmental impact of proposed federal activities is required by NEPA, as well as requires an examination of alternatives to those actions. Compliance with NEPA, as administered by DOE's NEPA Implementing Procedures (10 CFR 1021) and Council on Environmental Quality Regulations (40 CFR 1500–1508), ensures that consideration is given to environmental values and factors in federal planning and decision making. In accordance with 10 CFR 1021, the Paducah Site conducts NEPA reviews for proposed actions and determines if any proposal requires preparation of an environmental impact statement (EIS), an EA, or is categorically excluded (CX) from preparation of either an EIS or an EA. The Paducah Site maintains records of all NEPA reviews.

In 2000, the DOE Oak Ridge Operations Office determined that five actions at the Paducah Site met the criteria for CX. Three other activities were determined to be within the scope of previously approved CXs. In addition, numerous minor activities were within the scope of the previously approved CXs for routine maintenance, small-scale facility modifications, and site characterization. The Paducah DOE Site Office and the DOE Oak Ridge Operations Office NEPA compliance officer approve and monitor the internal applications of previously approved CX determinations.

A Finding of No Significant Impact (FONSI) was issued by DOE after completion of an EA for the treatment of mixed wastes at the Paducah Site using the Vortec vitrification system. In 2000, DOE also initiated preparation of two EAs. An EA will be prepared to address Waste Disposition. A second EA will be prepared to address the process and criteria for accepting Paducah Site waste at the C-746-ULandfill.

In accordance with the 1994 DOE Secretarial Policy Statement on NEPA, preparation of separate NEPA documents for environmental restoration activities conducted under CERCLA is no longer required. Instead, DOE CERCLA documents now incorporate NEPA values to the extent practicable. Actions conducted under CERCLA are discussed in the environmental restoration sections of this report.

National Historic Preservation Act

The NHPA of 1966 is the primary law governing federal agencies' responsibility for identifying and protecting historic properties (cultural resources included in, or eligible for inclusion in, the National Register of Historic Places). There are currently no historic properties at the Paducah Site in the National Register of Historic Places, although there is a potential for eligible historic properties. Therefore, each proposed project is assessed to determine if there are any historic properties present and whether they may be affected. In making these determinations, DOE consults with the SHPO as required by Section 106 of the NHPA.

In accordance with 36 CFR 800.13, DOE is in the process of developing an optional NHPA compliance strategy based on a programmatic agreement between DOE, the Advisory Council on Historic Preservation, and the SHPO. In April 1997, a draft programmatic agreement was submitted to the SHPO for approval. The draft programmatic agreement provides for a more comprehensive cultural resources program and requires a survey to identify significant historical properties and development of a Cultural Resources Management Plan. The draft programmatic agreement is still in the process of being finalized.

In 2000, no activities were conducted which adversely affected historic properties.

Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened animals and plants. The act also serves to protect ecosystems on which such species depend. At the Paducah Site, proposed projects are reviewed, in conjunction with NEPA project reviews, to determine if activities have the potential to impact these species. If necessary, project-specific field surveys are performed to identify threatened and endangered species and their habitats, and mitigating measures are designed as needed. When appropriate, DOE initiates consultation with the U.S. Fish and Wildlife Service prior to implementing a proposed project.

Table 2.2 includes nine federally-listed, proposed, or candidate species that have been identified as potentially occurring at or near the Paducah Site. Project NEPA reviews and associated field surveys indicated that in 2000, DOE projects at the Paducah Site did not directly impact any of these nine species. Potential habitats of these species were also not significantly impacted.

Floodplain/Wetlands Environmental Review Requirements

Title 10, Part 1022 of the CFR establishes procedures for compliance with Executive Order 11988, "Floodplain Management," and Executive Order 11990, "Protection of Wetlands." Activities, other than routine maintenance, proposed within 100-year floodplains or in wetlands first require that a notice of involvement be published in the *Federal Register*. A floodplain or wetlands assessment must then be prepared by DOE that evaluates potential impacts on the floodplains or wetlands and considers alternatives to avoid or lessen impacts. For floodplains, a floodplain statement of findings summarizing the floodplain assessment must be published in the *Federal Register* for public comment at least 15 days before beginning the project. Activities of DOE in "waters of the United States," which include wetlands, are likely to be

Table 2.2 Federally listed, proposed, and candidate species potentially occurring within the Paducah Site Study Area in 2000[a]

Common Name	Scientific Name	Endangered Species Act Status
Indiana Bat[b]	*Myotis sodalis*	Listed Endangered
Interior Least Tern	*Sterna antillarum athalassos*	Listed Endangered
Pink Mucket	*Lampsilis abrupta*	Listed Endangered
Ring Pink	*Obovaria retusa*	Listed Endangered
Orangefoot Pimpleback	*Plethobasus cooperianus*	Listed Endangered
Fat Pocketbook	*Potamilus capax*	Listed Endangered
Bald Eagle	*Haliaeetus leucocephalus*	Listed Threatened
Sturgeon Chub	*Macrhybopsis gelida*	Candidate
Sicklefin Chub	*Macrhybopsis meeki*	Candidate

[a] All of the above species are discussed in *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky, Volume III*, U. S. Army Corps of Engineers Nashville District, May 1994. Note that the study area encompasses 11,719 acres and extends to include the Ohio River, which is over three miles north of the DOE reservation. None of these species have been reported as sighted on the DOE reservation although potential summer habitat exists there for the Indiana bat. No critical habitat for any of these species has been designated anywhere in the study area.

[b] Specimens of the Indiana bat were collected at the WKWMA in 1991 and 1999.

subject to additional CWA permit requirements administered by the U.S. Army Corps of Engineers (COE) and may require water quality certification from KDEP.

In 2000, no floodplain or wetlands assessments were prepared or approved. Also, no floodplain or wetlands notices of involvement were published in the *Federal Register* for the Paducah Site. In addition, DOE did not apply for any individual permits from COE or for any water quality certifications from the state. Some DOE projects were authorized through the COE nationwide permit program for activities involving waters of the United States.

DOE activities did not result in significant impacts to floodplains or wetlands at the Paducah Site in 2000.

Farmland Protection Policy Act

Prime farmland is generally defined as land that has the best combination of physical and chemical characteristics for producing crops of statewide or local importance. The Farmland Protection Policy Act of 1981 requires federal agencies to consider the effects of their proposed actions on prime farmland and consider any alternatives that would lessen impacts. When required, prime farmland surveys are conducted, and DOE consults with the U. S. Department of Agriculture Natural Resources Conservation Service, formerly the Soil Conservation Service. If conversion of prime farmland is anticipated, a Farmland Conversion Impact Rating form is completed and submitted to the Natural Resources Conservation Service. No Farmland Conversion Impact Rating forms were submitted to the Natural Resources Conservation Service in 2000.

DOE activities did not result in conversion of any prime farmland in 2000.

Clean Water Act

The CWA was established primarily through the passage of the Federal Water Pollution Control Act Amendments of 1972. The CWA established the following four major programs for control of water pollution: (1) a permit program regulating point-source discharges into waters of the United States, (2) a program to control and prevent spills of oil and hazardous substances, (3) a program to regulate discharges of dredge and fill materials into "waters of the U.S.," and (4) a program to provide financial assistance for construction of publicly owned sewage treatment works. The Paducah Site is primarily affected by the regulations for discharges of dredge and fill materials (see previous subsection on Floodplain/ Wetlands Environmental Review Requirements) and for point-source discharges regulated under the KPDES.

Kentucky Pollutant Discharge Elimination System

During 2000, the CWA applied to all nonradiological DOE discharges to waters of the United States. At the Paducah Site, the regulations are applied through issuance of a KPDES permit for effluent discharges to Bayou and Little Bayou creeks. The Kentucky Division of Water (KDOW) issued KPDES Permit No. KY0004049 to the Paducah Site. This permit became effective April 1, 1998, and is enforced by the KDOW. The KPDES permit calls for biological monitoring as an indicator of discharge related effects in the receiving stream.

KPDES Permit No. KY0004049 applies to the following four outfalls: 001, 015, 017, and 019. Outfall 001 had two permit exceedences during 2000. Both exceedences were due to chronic toxicity. Testing indicated that a pathogen in the USEC owned and operated C-616 Full Flow Lagoon was responsible for the toxicity found in Outfall 001. No exceedences of effluent limits occurred at Outfall 015, which is a rainfall-dependent outfall. Two permit exceedences occurred at Outfall 017, which contains runoff from DOE depleted uranium hexafluoride (DUF_6) cylinder storage yards. Both exceedences were due to acute toxicity, most likely related to zinc from paint associated with newly painted DUF_6 cylinders. No exceedences of effluent limits occurred at C-746-U Landfill Outfall 019. The toxicity problems associated with Outfalls 001 and 017 are discussed in detail in the following subsections and in Section 7.

Toxicity at Outfall 001

As a result of quarterly routine compliance sampling of KPDES Outfall 001, toxicity to fathead minnows was identified in 1999. The KPDES permit requires a fathead minnow (*Pimephales promelas*) growth test and water flea (*Ceriodaphnia dubia*) life-cycle test of Outfall 001 to be conducted quarterly to evaluate wastewater toxicity. Toxicity testing of the outfall, performed the third week of July 1999, failed the fathead minnow standard established in the permit, but passed the water flea evaluation. A retest for fathead minnow toxicity was conducted within 14 days of the first failure. Results from the retest also failed the fathead minnow growth standard. Results from these toxicity evaluations were reported in the Discharge Monitoring Report (DMR) for the July through September 1999 monitoring period. Upon receipt of the toxicity results, KDOW issued an NOV to DOE November 23, 1999. Remedial measures required DOE to immediately commence monthly toxicity monitoring at Outfall 001 and submit a Toxicity Reduction Evaluation (TRE) plan to KDOW. A TRE Plan was submitted to KDOW December 21, 1999.

Toxicity data from the DMR and TRE tests indicated that the failures were probably due to a fish pathogen (biological agent causing disease) in the effluent of the USEC C-616 Full Flow Lagoon. Based on this information, simultaneous toxicity tests were conducted on untreated USEC C-616 Full Flow Lagoon effluent and effluent treated with an antibiotic to kill any pathogen present. The untreated effluent displayed the same degree of toxicity as the previous test, while the effluent

treated with an antibiotic was not toxic to the fathead minnows.

The TRE continued into 2000 with monthly chronic toxicity testing. Outfall 001 was found to be toxic in February (1.62 toxicity units) and March (4.5 toxicity units). As discussed previously, the source of the toxicity was found to be a naturally occurring pathogen in the receiving waters of Outfall 001. The state regulators stopped the TRE process in May, indicating that toxicity was back within permit conditions. Toxicity testing was returned to a quarterly schedule and no further toxic results were seen in 2000. No NOVs were received in 2000 for toxicity.

Toxicity at Outfall 017

On December 18, 1998, routine quarterly test results from an acute toxicity test on Outfall 017 were received from an off-site laboratory. Outfall 017 is a storm water runoff outfall located west of the PGDP access road. The sample had been collected October 6, 1998, and the acute toxicity was measured by the laboratory at 1.5 acute Toxicity Units (TUa). A retest was initiated with the next rainfall December 21, 1998, and results of that retest were received December 28, 1998. The retest was measured at 2.2 TUa. Because the toxicity exceeded 1.2 times the TUa limit of 1.0 TUa for both samples, a TRE plan was required by the KPDES permit. Two organisms were required to be tested per the KPDES permit: (1) water fleas (*Ceriodaphnia dubia*) and (2) fathead minnows (*Pimephales promelas*). Both of the failing toxicity tests indicated no toxicity with full-strength water to the fathead minnows, but 100% toxicity to the water fleas.

In accordance with permit requirements, KDOW was verbally notified December 28, 1998, of the failure of the two consecutive tests, and by formal letter from the DOE Paducah Site Office within the five-day legal notification requirement. A draft TRE Plan was sent to KDOW January 29, 1999. Verbal approval of the plan was received February 24, 1999. Also, approval was granted to test only water fleas and not fathead minnows.

Operations contained in the watershed for Outfall 017 included the cylinder storage yard operations and the nonoperational cylinder painting facility. The last cylinder was removed from the cylinder painting area September 25, 1998, and no activity occurred at the location following that date. Sampling of C-745-G Cylinder Yard Pit, which collects water from the cylinder painting area and C-745-G Cylinder Storage Yard, was initiated following the retest of Outfall 017. The toxicity was measured at 1.47 TUa indicating that the area draining into the C-745-G Pit was toxic. With the next rainfall on January 22, 1999, samples were taken at locations discharging into Outfall 017. Results indicated the western side of C-746-G Cylinder Yard was toxic and the combined discharge of cylinder yards C-746-T, S, F, H, and K were also toxic. Also, Outfall 017 continued to be toxic and the runoff from the access road near Outfall 017 was toxic. Further testing revealed that the cylinder painting area and cylinder storage yards where newly painted cylinders were stored produced toxic runoff during rainfall.

Chemical analysis and toxicity testing was conducted on the previously mentioned samples. Ethylenediaminetetraacetic acid (EDTA) tests indicated that metals were the toxic constituent in the runoff. When added to a sample, EDTA ties up the metals and makes them unavailable for uptake by biological organisms. Filtering of the samples indicated that the toxic constituent was dissolved in the toxic samples. Zinc was identified as being a contaminant that might be of concern due to its elevated presence in toxic samples. A literature search, and addition of zinc to clean water adjusted to consistent hydrogen-ion concentration (pH) and hardness, indicated that in the toxicity tests the zinc alone was probably not toxic in the levels found in toxic samples. Other factors and other chemicals present may have had a synergetic effect to produce toxicity. The TRE was carried on throughout 1999 with all evidence pointing to zinc associated with recently painted cylinders as the leading contributor to Outfall 017 toxicity. Cylinder painting was not conducted in 1999.

The TRE continued throughout 2000 with monthly acute toxicity testing. One of two tests conducted in January had a toxicity level of 1.36 TUa, which was above the standard of 1.0. Toxicity was also seen in the February test at 1.41 TUa. Monthly testing continued throughout the year with no exceedences of the standard. The lack of toxicity may be an indication of no further toxic constituents washing off of painted cylinders or the toxicity could return with hard spring rains in 2001, as has occurred in 1999 and 2000. No NOVs associated with toxicity at Outfall 017 were issued in 2000.

On August 30, 2000, DOE, BJC, and KDOW representatives met to discuss the path forward concerning the intermittent acute toxicity permit exceedences over the past two years at Outfall 017. It was agreed that DOE would submit a request to KDOW to continue the TRE investigation to identify the dynamics of the intermittent toxicity exceedences. On September 15, 2000, a proposed TRE plan was submitted by DOE to KDOW. This proposed plan was to be implemented from October 2000 through March 2001. In correspondence from KDOW to DOE dated October 17, 2000, comments were received on the draft TRE Plan. In correspondence dated October 23, 2000, a revised TRE plan incorporating the comments was submitted by DOE to KDOW. The revised plan indicated that implementation would be from November 2000 through April 2001. This TRE plan was approved by KDOW. Due to samples not being collected in November 2000, the TRE investigation will continue through at least May 2001.

Toxic Substances Control Act

In 1976, TSCA was enacted with a twofold purpose: (1) to ensure that information on the production, use, and environmental and health effects of chemical substances or mixtures are obtained by the EPA, and (2) to provide the means by which the EPA regulates chemical substances/ mixtures.

Polychlorinated Biphenyls

The Paducah Site undertakes activities to comply with PCB regulations (40 CFR 761) and the Uranium Enrichment (UE) TSCA FFCA promulgated under TSCA. The major activities performed in 2000 to ensure compliance included the following: maintaining compliant storage of PCB waste and PCB-contaminated wastewater, shipping PCB waste for treatment and disposal, treatment and discharge of PCB-contaminated wastewater, maintenance to the troughing system, and reporting and record keeping.

The UE TSCA FFCA between EPA and DOE was signed in February 1992. To meet the compliance goals at the Paducah Site, the UE TSCA FFCA is frequently revised and updated. Under this agreement, action plans have been developed and implemented for removal and disposal of large volumes of PCB material at the Paducah Site. As part of this program during 2000, 55 capacitors were removed from service. Table 2.3 shows progress of removal of capacitors in service during the year. Table 2.4 is a summary of PCB items in service at the Paducah Site at the end of 2000.

Twenty-two boxes containing 1336 capacitors were shipped off-site for disposal in 2000. The contents of the boxes shipped on September 11, 2000, by Paducah to Clean Harbors were inappropriately buried at the Model City Landfill in New York. The New York State Department of Conservation and EPA Region II are investigating the incident.

The annual PCB document, due July 1, provides details of facility activities associated with the management of PCB materials. The annual report provides details from the previous year on all PCB items that are in use, stored for reuse, generated as waste, stored for disposal, or shipped off-site for disposal. All Paducah Site UE TSCA FFCA milestones for 2000 were completed.

Table 2.3 Status of large, high-voltage PCB capacitors in 2000

Building Location	Beginning Balance (1/1/00)	Capacitors Removed	New Balance (12/31/00)
C-331	69	0	69
C-333	413	0	413
C-335	46	0	46
C-337	310	55	255
Total	838	55	783

Table 2.4 Summary of PCBs and PCB items in service at the end of 2000

Type	Number in Service	Volume (gal)	PCBs (kg)
PCB transformers	66	95,256	277,152
PCB-contaminated transformers	10	2,699	1.27
PCB-contaminated electrical equipment	7	2,094	1.13
PCB capacitors	783	--	--
PCB open systems[a]	3	235	7.02

[a] PCB open systems are addressed in the UE TSCA FFCA. In addition, ventilation gaskets used in various buildings throughout the Paducah Site have been determined to contain PCBs. The average PCB concentration is estimated to be 20% by weight. The total PCB content is estimated at 3840 kg in the 19,200 kg of gaskets.

The facility operates equipment that contains PCB capacitors as well as transformers, electrical equipment, and other miscellaneous PCB equipment. Both radioactive and nonradioactive PCB wastes are stored on-site in storage units that meet TSCA and/or UE TSCA FFCA compliance requirements. Upon approval, nonradioactive PCBs are transported off-site to EPA-approved facilities for disposal. Radioactively contaminated PCB wastes are authorized by the UE TSCA FFCA for on-site storage beyond two years. Technology for the treatment and/or disposal of radioactively contaminated PCB wastes is being evaluated.

Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA regulates the manufacture, storage, and application of pesticides. No restricted-use pesticides are used by Paducah Site personnel. If application of a restricted-use pesticide at the plant was necessary for DOE activities, a certified contractor would be used. General-use pesticides are applied by plant personnel in a manner consistent with product labeling; all product warnings and cautions are strictly followed.

Emergency Planning and Community Right-To-Know Act

Also referred to as Title III of the Superfund Amendments and Reauthorization Act (EPCRA), requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment. Reports under EPCRA are submitted to federal, state, and local authorities. Executive Order 12856, signed in August 1993, subjects all federal agencies to EPCRA. The applicable requirements of EPCRA are contained in Sections 304, 311, 312, and 313.

- Section 304 requires reporting of off-site reportable quantity releases to state and local authorities.

- Section 311 requires that either material safety data sheets (MSDSs) or lists of the hazardous chemicals for which an MSDS is required be provided

to state and local authorities for emergency planning purposes.

- Section 312 requires that a hazardous chemical inventory be submitted to state and local authorities for emergency planning.

- Section 313 requires annual reporting of releases of toxic chemicals to the EPA and the state.

The Paducah Site did not have any releases that were subject to Section 304 notification requirements during 2000. No Section 311 notifications were required in 2000. The Section 312 Tier II report of inventories for 2000 included UF_6, uranium tetrafluoride (UF_4), kerosene, magnesium fluoride, and PCBs associated with DOE activities. The Paducah Site reported PCBs on the Section 313 report, based on the disposal of electrical equipment.

Clean Air Act

Authority for enforcing compliance with the CAA and subsequent amendments resides with EPA and the Kentucky Division for Air Quality (KDAQ). The Paducah Site maintains compliance with federal and state rules implementing the CAA and its amendments.

Clean Air Act Compliance Status

The Paducah Site had two air emissions point sources in 2000. The Northwest Plume Groundwater System and the Northeast Plume Containment System are interim remedial actions (IRAs) for the containment of groundwater contamination at the Paducah Site. These separate facilities remove trichloroethene (TCE) contamination from the groundwater by air stripping. At the Northwest Plume Groundwater System, the TCE-laden air passes through carbon filtration which removes much of the TCE. The air stream is then released to the atmosphere where the remaining TCE naturally breaks down. The Northwest Plume Groundwater System removed approximately 2294 pounds (190 gallons) of TCE from the groundwater in 2000. Therefore, a portion of the TCE, a CAA hazardous air pollutant, was released to the atmosphere. Approximately 186 pounds (15 gallons) of TCE were also released from the C-337 Cooling Tower, a part of the Northeast Plume Containment System (Section 3).

Asbestos Program

Numerous facilities at the Paducah Site contain asbestos materials. Compliance programs for asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures and program plans are maintained that delineate scope, roles, and responsibilities for maintaining compliance with EPA, Occupational Safety and Health Administration, and Kentucky regulatory requirements. Noncompliances with environmental protection standards were not identified in 2000.

Radionuclide National Emissions Standards for Hazardous Air Pollutants Program

Kentucky and EPA regulate airborne emissions of radionuclides from DOE facilities under 40 CFR 61 Subpart H, the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. Potential radionuclide sources at the Paducah Site in 2000 were the Drum Mountain Removal Project, Northwest Plume Groundwater System, and fugitive emissions sources. The fugitive emission sources include piles of contaminated scrap metal, roads, and concrete rubble piles. DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient air data were collected at eight sites surrounding the plant in order to measure radionuclides emitted from Paducah Site sources, including fugitive emissions. The Radiation/

Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services conducted ambient air monitoring during 2000. The monitoring network only detected Americium-241 (^{241}Am) during the first quarter of 2000 at one station location northeast of the plant.

The concentration was 2.6 x 10^{-16} curie/cubic meter. This is less than the threshold level that could have a health effect, as established by EPA in 40 CFR 61, Appendix E, Table 2.

Pollutants and Sources Subject to Regulation

Any stationary source emitting more than 10 tons/year of any Hazardous Air Pollutant (HAP) or 25 tons/year of any combination of HAPs is considered a major source and is subject to regulation. EPA must examine other sources for regulation under an "area source" program. The Paducah Site is not a major source by virtue of its individual or total hazardous air pollutant emissions.

Stratospheric Ozone Protection

DOE only has refrigeration units that contain less than 50 pounds of listed substances; therefore, the only part of this regulation that applies to the Paducah Site is the requirement to control refrigerants from leaking systems and maintain records of systems disposed. DOE has implemented these controls and has an established record keeping system.

Clean Air Act NOVs

An NOV dated July 24, 2000, was received by DOE from the KDAQ Paducah Office. The NOV was issued based on July 13, 2000, observations from an inspection of the Drum Mountain removal project. The violation identified in the NOV stated the following: "Reasonable precautions were not being taken to prevent particulate matter from becoming airborne from the Drum Mountain baler and associated transfer point. The Drum Mountain baler and associated transfer point as well as their associated air pollution control equipment, were not being maintained and operated in a manner consistent with good air pollution control practices to minimize emissions." The regulatory citation for the NOV was KRS 224. DOE subsequently improved emission control and KDAQ agreed to allow resumption of the project.

Another NOV dated July 28, 2000, was received by DOE from the KDAQ Paducah Office. The violation identified in the NOV was stated as the following: "Denial of Cabinet personnel entrance to Drum Mountain for the purpose of inspection for the ascertaining of compliance. Entry for the inspection of Drum Mountain removal project was denied for a period of one hour and three minutes." DOE did not concur with the NOV, but offered to provide safety training and initiate security clearances for inspectors in order to expedite future entries to the plant.

Kentucky/Department of Energy Agreement in Principle

The Kentucky/DOE Agreement in Principle (AIP) reflects the understanding and commitments between DOE and the commonwealth of Kentucky regarding DOE's provision of technical and financial support to Kentucky for environmental oversight, surveillance, remediation, and emergency response activities. The goal of the AIP is to maintain an independent, impartial, and qualified assessment of the potential environmental impacts from present and future DOE activities at the Paducah Site. The AIP is intended to support non-regulatory activities whereas the FFA covers regulatory authority. The AIP includes a grant to support the commonwealth of Kentucky in conducting independent monitoring and sampling, both on-site and off-site, and to provide support in a number of emergency response planning initiatives including cooperative planning, conducting joint training exercises, and developing public information regarding preparedness activities. The AIP is

Table 2.5 State and federal regulatory inspections at the Paducah Site in 2000

Date	Auditor	Description
January 2000	KDAQ	Inspection of North/South Ditch Excavation (2 visits). (Findings--None)
January 2000	KDAQ	Inspection of North/South Ditch Excavation (Asbestos) (Findings--None)
March 2000	KDWM	Inspection of Abandonment of Well 181 (Findings--None)
March 2000	KDOW	Inspection of DOE KPDES Outfalls (Findings--None)
April 2000	KDWM	View Stage 1 Inspection of DMSA-004 in C-400 (Findings--None)
May 2000	KDWM	Inspection of Closure of C-720 Sump Work (Findings--None)
May 2000	KDAQ	Inspection of Ambient Air Monitoring Stations Operated by Kentucky Cabinet for Human Services (Findings--None)
June 2000	KDWM	Inspection of C-746-U Contained Landfill (Findings--None)
June 2000	KDAQ	Inspection of Drum Mountain Removal Project (Findings--None)
June 2000	KDOW	Inspection of DOE KPDES Outfalls (Findings--None)
July 2000	KDWM	C-404 Landfill Inspection (July 10) [Findings—None]
July 2000	KDWM	C-400 DMSA Inspection (July 11) (Findings--None)
July 2000	KDWM, EPA, and DOJ	DMSA Inspection (July 31 - August 4) (Findings--None)
July 2000	KDAQ	Drum Mountain Removal Project (July 13) (Findings--NOV)
		NOV on July 25 - Fugitive emissions from Drum Mountain Project (based on July 13 visit)
July 2000	KDAQ	Drum Mountain Removal Project (July 24) (Findings--None)
July 2000	KDAQ	Drum Mountain Removal Project (July 26) (Findings--None)
July 2000	KDAQ	Drum Mountain Removal Project (July 28) (Findings--NOV)
		NOV on July 28 - Denial of Cabinet personnel entrance to Drum Mountain for purpose of inspection [entry for the inspection was denied for a period of one (1) hour and three (3) minutes]
August 2000	KDAQ	Inspection of Drum Mountain Removal Project (August 11) (Findings--None)
August 2000	KDAQ	Inspection of Drum Mountain Removal Project (August 15) (Findings--None)
August 2000	KDAQ	Inspection of Drum Mountain Removal Project (August 29) (Findings--None)
September 2000	KDWM	DMSAs (September 5) (Findings--NOV)
		NOV on September 5 for failure to comply with RCRA Permit Condition IV.B
September 2000	KDWM	September 9 (Findings--None)

Table 2.5 State and federal regulatory inspections at the Paducah Site in 2000 (Continued)

Date	Auditor	Description
September 2000	KDWM	DMSA's September 5 (Findings--NOV) NOV on September 5 for failure to comply with RCRA Permit Condition IV.B
September 2000	KDWM	September 9 (Findings--None)
September 2000	KDAQ	September 21 (Findings--None)
September 2000	KDOW	September 28 (Findings--None)
October 2000	KDWM	Inspection of the C-746-U Landfill (October 17) (Findings--None)
November 2000	KDAQ and Region IV EPA	Inspection of the Paducah NESHAP Air Emission Sources and ambient air monitoring stations operated by Kentucky Cabinet for Human Resources (Radiation Health and Toxic Substances Branch) (November 29-30) (Findings--None)
December 2000	KDOW	Inspection of KPDES outfall (December 11) (Findings--None)
December 2000	KDWM /KDAQ	Inspection of C-400-04 DMSA (December 18) (Findings--None)

negotiated on a five-year interval. The AIP's second five-year agreement became effective January 1, 1997.

Assessments

Paducah Site environmental management programs are overseen by several organizations, both inside and outside the DOE complex. Each year, numerous appraisals, audits, and surveillances of various aspects of the environmental compliance program are conducted. Table 2.5 summarizes of the assessments conducted in 2000.

3 Environmental Program Information

Abstract

Environmental monitoring, environmental restoration, waste management, and UF_6 cylinder management activities occur at the Paducah Site. Several programs are conducted, therefore they are presented in this section to inform the public about these activities.

Environmental Monitoring Program

The Environmental Monitoring Program at the Paducah Site consists of effluent monitoring and environmental surveillance. Requirements for routine environmental monitoring programs were established to measure and monitor effluents from DOE operations and maintain surveillance on the effects of those operations on the environment and public health through measurement, monitoring, and calculation. This program is intended to demonstrate that DOE operations at the Paducah Site comply with DOE orders and applicable federal, state, and local regulations. The Environmental Monitoring Program is documented in the Paducah Site Environmental Monitoring Plan in accordance with DOE Order 5400.1, *General Environmental Protection Program.* The results of this program are discussed in detail in subsequent sections of this ASER.

Before the DOE/USEC transition (described in Section 1), DOE's primary mission at the Paducah Site consisted of enriching uranium. However, since the transition on July 1, 1993, DOE's mission at the site has been focused on environmental restoration, DUF_6 cylinder management, and waste management. This change in mission has also changed the direction and emphasis of the Environmental Monitoring Program. In November 1995, the site Environmental Monitoring Plan was reissued to address DOE operations exclusively. The Environmental Monitoring Plan is reviewed annually and updated at least every three years. The 1999 version of the Environmental Monitoring Plan (BJC 1999) addresses the sampling events in 2000 that are reported in this ASER. Data Quality Objective (DQO) sessions were held during June and August of 2000 in order to determine if additional monitoring or changes to the environmental monitoring program were needed for 2001. As a result, locations and parameters

were added for surface water, sediment, and groundwater monitoring in 2001.

Environmental Restoration Program

The goal of the Environmental Restoration Program is to ensure that releases from past operations and waste management activities are investigated and that appropriate remedial action is taken for the protection of human health and the environment. In May 1994, the PGDP was added to EPA's NPL of hazardous waste sites that require the most cleanup. Two federal laws, RCRA and CERCLA, are the dominant regulatory drivers for environmental restoration activities at the Paducah Site. RCRA sets the standards for managing hazardous waste and requires permits to be obtained for DOE facilities that treat, store, or dispose of hazardous waste and requires assessment and cleanup of hazardous waste releases at facilities. CERCLA addresses uncontrolled releases of hazardous substances and requires cleanup of inactive waste sites.

Background

In July 1988, the Kentucky Radiation Control Branch, in conjunction with the Purchase District Health Department, sampled several residential groundwater wells north of the plant in response to concerns from a local citizen regarding the quality of water in a private well. Subsequent analyses of these samples revealed elevated gross beta levels, indicative of possible radionuclide contamination. On August 9, 1988, these results were reported to the Paducah Site, which responded by sampling several private groundwater wells adjacent to the site August 10, 1988. Upon analysis, some of the samples collected contained elevated levels of both TCE and ^{99}Tc. In response, DOE immediately instituted the following actions:

- provided a temporary alternate water supply to affected residences,
- sampled surrounding residential wells to assess the extent of contamination,
- began extension of the municipal water line to affected residences as a long-term source of water, and
- began routine sampling of residential wells around the Paducah Site.

Following the initial response actions, DOE and EPA entered into an ACO in August 1988 under sections 104 and 106 of CERCLA. The major requirements of the ACO include monitoring of residential wells potentially affected by contamination, providing alternative drinking water supplies to residents with contaminated wells, and investigation of the nature and extent of off-site contamination.

Pursuant to the ACO, DOE continued routine sampling of residential wells and initiated a two-phase site investigation to identify the nature and extent of off-site contamination at the Paducah Site. Phase I of the site investigation, from summer 1989 to March 1991, evaluated the extent of off-site contamination at the Paducah Site through extensive groundwater monitoring and surface-water sampling. Results of these activities are reported in *Results of the Site Investigation, Phase I, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991b). Phase II of the site investigation, from November 1990 to October 1991, focused on identification and characterization of on-site sources contributing to off-site contamination, determined the level of risk to human health and the environment from exposure to contaminated media and biota, and developed an initial list of remedial alternatives. Results are reported in *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992a). The principal findings of the site investigation are as follows:

- TCE and ^{99}Tc were identified as the primary contaminants in off-site groundwater at the Paducah Site.
- A northwest and a northeast groundwater plume extending off-site were delineated.

- PCBs and radionuclides were identified as the primary contaminants detected in surface water and sediment in outfalls, ditches, and creeks around the Paducah Site.
- Several on-site sources were identified as potential contributors to off-site contamination.

Risks to human health and the environment from exposure to contamination originating at the Paducah Site were reported in *Results of the Public Health and Ecological Assessment, Phase II at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992b). This report used data collected during the site investigation to quantitatively assess risks to human health and to qualitatively assess risks to the environment.

A range of preliminary alternatives that could be used to address the contamination was also developed as part of the ACO activities. This information was presented in *Summary of Alternatives for Remediation of Off-Site Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (Draft) (SAIC 1991). Upon completion of the Phase II activities and in response to the risks identified in the public health and ecological assessment, the Paducah Site developed and implemented several IRAs designed to prevent further migration of contaminants and reduce risks to human health and the environment. The actions targeted certain on-site sources and the off-site contamination associated with groundwater and surface water.

As part of the routine residential well sampling that began when off-site contamination was discovered, DOE established a water policy. This policy states that in the event contamination originating from the Paducah Site is detected above plant-action levels, which are established at the analytical laboratory detection limits of 25 picoCuries per liter (pCi/L) for ^{99}Tc and 1 part per billion (ppb) for TCE, a response would be initiated by the Paducah Site. Accordingly, residents would be notified immediately as would state and EPA officials. Alternative water supplies would be provided through connection to the municipal water system, or in the event of a time lapse between discovery and the ability to complete connections, bottled water would be made available. DOE pays the cost of installation of water systems and the monthly charges for water service to residents with contaminated wells.

DOE modified this water policy to include provisions to extend a municipal water line to the entire area potentially affected by groundwater contamination originating from the Paducah Site. All residents within a defined area, regardless of whether or not their wells were contaminated, were given the option to receive municipal water at DOE's expense. Of the 83 eligible property owners, 73 signed agreements to accept the water provision and not to use or dig wells for human consumption on their property. DOE also provides municipal water to new residents and some new businesses. A five-year review of the water policy was issued in 1999.

Because of the extension of the municipal water line, the new water policy allows reduction in the number and frequency of residential wells sampled routinely. This modification provides for a more cost-effective allocation of well-sampling resources. Through the strategic placement of additional MWs, the modification also allows more accurate data on location and movement of contaminated groundwater.

The most significant interim action taken under the ACO, documented in *Technical Memorandum for Interim Remedial Action of the Northwest Plume* (DOE/OR/1031&D2), included groundwater extraction and treatment to reduce the spread of contamination from the source and high concentration areas of the Northwest Plume. The *Proposed Plan for Interim Remedial Action of the Northwest Plume* (DOE/OR/06-1127&D2), which summarizes the interim alternatives, was approved by EPA April 15, 1993. The *Record of Decision for Interim Remedial Action of the Northwest Plume* (DOE/OR/06-1143&D2) was signed by DOE July 15, 1993, and by EPA July 22, 1993. Construction of the interim action (the C-612 Northwest Plume Groundwater System) was completed and operational August 28, 1995.

A second groundwater remediation action, the *Record of Decision (ROD) for Interim Remedial Action (IRA) at the Northeast Plume* (DOE/OR/06-1356&D2), was signed by DOE June 13, 1995, and the EPA June 1, 1995. The ROD called for the hydraulic containment and treatment of high concentrations of off-site TCE contamination in the Northeast Plume.

Other interim actions completed to date include the North-South Diversion Ditch, institutional controls for surface water/ditches and scrapyards, enhancement of the existing cap for Waste Area Group (WAG) 7 (C-746-K Landfill), and a removal action at WAG 17 (AOC 124) , and a PCB removal action for surface soils at WAG 23 sites. The North-South Diversion Ditch Interim Action called for treating certain plant effluents and controlling the migration of contaminated sediment associated with the ditch. The installation of fencing/posting restricted recreational use of surface water, outfalls, and lagoons. The installation of sediment controls to mitigate surface-water/sediment runoff from scrapyards has been completed and is inspected on a monthly basis. The existing cap for the C-746-K Landfill was enhanced to reduce leachate migration from surface infiltration.

Environmental Restoration Program Activities

The Environmental Restoration Program supports remedial investigations (RIs) and response actions, decontamination and decommissioning (D&D) of facilities no longer in use, projects designed to demonstrate advancements in remedial technologies, and other projects related to remedial action for the protection of human health and the environment.

Operable Units

PGDP has numerous SWMUs and AOCs that require further investigation and potential remediation. Complex sites with multiple environmental releases, such as PGDP, may choose to divide the site into smaller areas and conduct separate RI feasibility studies (FSs), as opposed to conducting a single, site-wide RI/FS. These smaller, individual study areas, referred to as operable units (OUs) implying an area for action to be taken or WAGs under the FFA, typically contain a limited number of SWMUs/AOCs grouped together based on certain criteria.

The SWMUs and AOCs requiring an RI/FS were initially segregated into 30 WAGs based on the following characteristics, and then prioritized for cleanup according to their contributions to off-site contamination:

- Common Remedial Technologies,
- Common Contaminant Sites,
- Common Geographic Locations,
- Common Operational Processes,
- Common Release Mechanisms,
- Common Surface-Water Drainage,
- Common Media Type,
- Hydraulically-Connected Areas,
- Operating Units, and
- Suspected Sources of Off-site Contamination.

As a better understanding of site conditions was gained through the various WAG investigations, the agencies concluded it would be more effective if the existing WAGs were grouped more broadly, thereby providing the framework to more effectively integrate, focus, and prioritize response actions across the site. These data and other process knowledge were used to develop site conceptual models for each of the source areas to support the further consolidation of the WAGs into larger operable units. Source areas that were suspected as primary contributors of contamination to a specific environmental media and/or exposure pathway were grouped under the same OU. This effort resulted in identification of the following five potential OUs:

(1) Groundwater OU,

(2) Surface Water OU,

(3) Burial Grounds OU,

(4) Soils OU, and

(5) D&D OU.

The OUs include a number of SWMUs and AOCs that require an RI/FS. The scopes of these OUs are intended to include both the contributing source area and the affected media, which is a significant change from the previous WAG strategy where sources were addressed separately from the contamination that had already migrated to groundwater and surface water. Combining the source areas and affected media under the OU approach is intended to enhance the agencies' ability to develop integrated remedial solutions that will account for interactions between source areas and affected media.

While the source areas have been grouped into OUs based on suspected releases to a common media and/or exposure pathway, this does not mean the strategies or response actions for a given OU will not evaluate impacts to other media or exposure pathways. For example, the intent of the Soils OU is to help focus data collection and decision-making on a group of source areas where the probable site conditions, based on existing data and process knowledge, suggest the contamination may primarily be limited to the shallow soil horizons, thereby providing a primary route of exposure to plant workers through direct contact. However, it is not unrealistic for some sources within this OU to also be a contributor to surface water or groundwater via contaminant transport. In comparison, sources in the groundwater and surface water OUs may also contain contamination at locations where plant workers could experience direct contact exposure with contaminated soils or sediments. Therefore, the strategies and corresponding response actions will contain adequate flexibility to manage uncertainties and address impacts to other media and secondary routes of exposure when appropriate.

Also, it should be noted that some OUs contain operating SWMUs. Since some of these units may not be able to be fully characterized or remediated until they cease operation, the scope of the RI/FS may be focused in nature, with emphasis on the migration pathways to determine whether there is an on-going release that poses a current risk, which warrants an immediate action. However, the extent of investigation and remedial action for OUs will be determined on a case-by-case basis after consideration of site-specific conditions. In some cases, if the investigation determines there is no immediate risk or potential for off-site migration, additional characterization and/or remediation may be deferred to the D&D OU when these units cease operation.

Once the five OU actions are complete, a comprehensive site-wide OU (CSOU) will be conducted. The scope of the CSOU will include a comprehensive site-wide baseline risk assessment to evaluate any residual risk remaining at the site after completion of the five OUs, and the cumulative effects from all media. If the CSOU risk assessment concludes the actions taken to date collectively provide adequate protection to human health and the environment, a final CSOU Proposed Plan and ROD will be issued. The ROD will be followed by a final remediation report declaring site remediation complete. In the event the CSOU risk assessment determines additional actions are needed, an FS will be developed with the preferred alternative documented in a proposed plan and ROD, followed by the necessary remedial actions prior to issuing the final remediation report.

Site Priorities

The prioritization process for implementing the OU strategy incorporates the general principles of the National Contingency Plan, which emphasizes the use of early actions to address and reduce further migration of imminent threats (both on- and off-site) and contamination (Figure 3.1). Consistent with those principles, a series of interim actions were implemented under the ACO during the earlier phases of the cleanup program. These actions focused exclusively on mitigating current

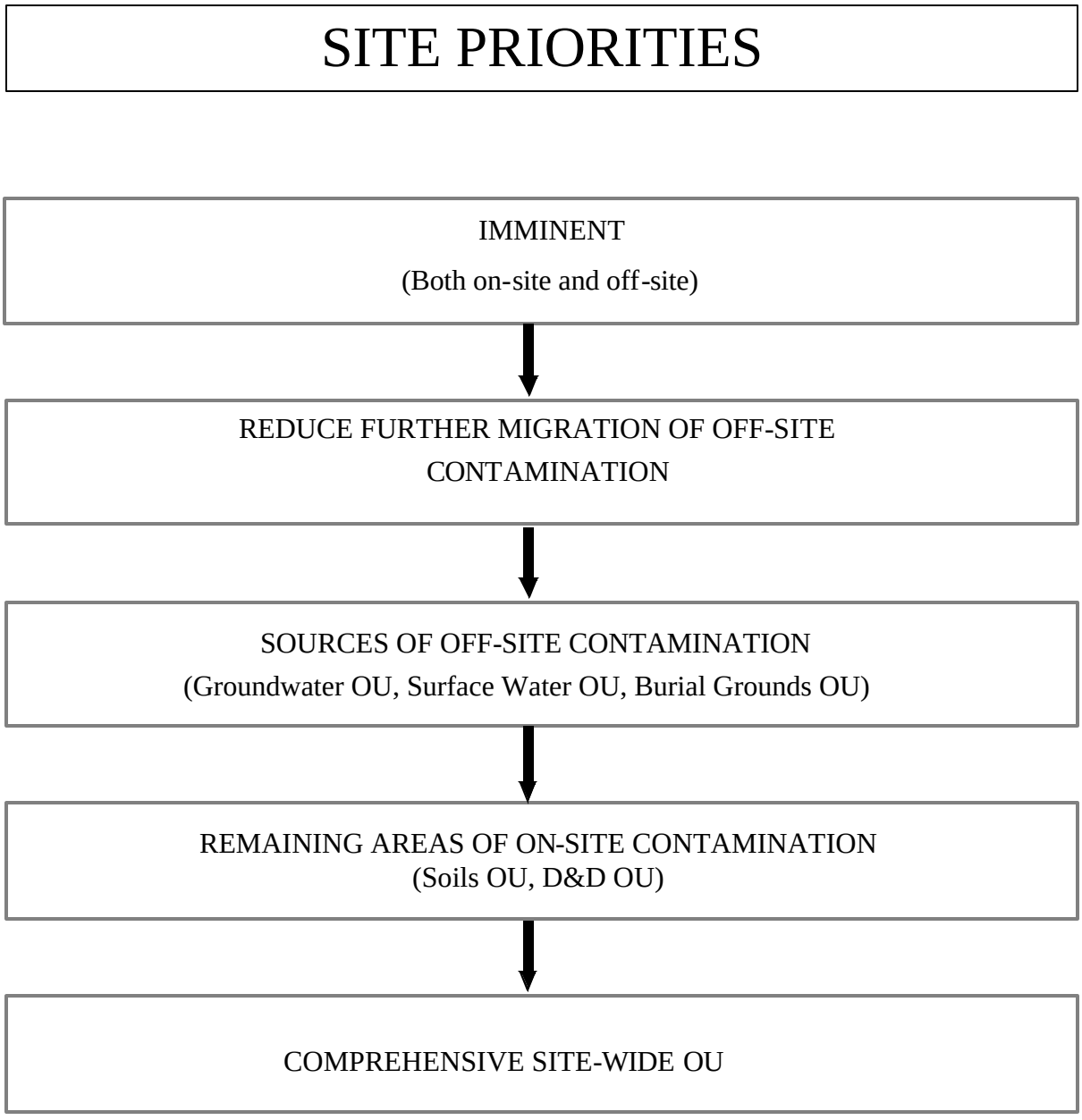


Figure 3.1 Site management plan priorities and corresponding projects.

threats of that nature, including, for example, alternate drinking supplies to affected residents, construction and operation of groundwater treatment systems for the northwest and northeast plumes, and surface water actions in the North-South Diversion Ditch and Bayou and Little Bayou creeks. With regard to potential on-site exposure, current threats, in general, have been mitigated through access restrictions and institutional controls. However, data generated from implementation of the OU strategy will be continuously reviewed to identify the need, should current threats be discovered, for additional expedited action.

Assuming imminent threats have been adequately addressed through previous actions, groundwater and surface water have been identified as the highest priority since those media serve as migration pathways to off-site receptors. The Soils and Burial Grounds OUs are the next priority followed by the D&D facilities. However, it should be noted that while the RI/FSs for the five OUs have been sequenced in accordance with the previous priorities, a key strategy of implementing the OU approach is early evaluation of existing data to help identify opportunities to implement early actions prior to, or in conjunction with, the RI/FSs for each OU. While a series of early actions have already been identified for several of the OUs (e.g., Scrap Metal, North-South Diversion Ditch, C-340/C-410 D&D, etc.), this revised strategy formalizes a process to further facilitate identification and implementation of early actions.

2000 Remedial Activities

The significant accomplishments for the environmental restoration program conducted in 2000 include the following:

- Continued operation of the Lasagna™ technology as the selected remedial alternative for reducing the concentration of TCE in SWMU 91.
- Removal of Drum Mountain from the Paducah Scrap Yards.
- Completed mobilization for the permeable Treatment Zone (PTZ) study.
- Continued operation of the Northwest and Northeast Plume Groundwater treatment systems.

Lasagna™

In July 1998, DOE issued the *Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998). The ROD designated Lasagna™ as the selected remedial alternative for reducing the concentration of TCE in SWMU 91 to levels that would decrease the potential groundwater risk to human health and the environment at the point-of-exposure (POE).

Lasagna™ was selected as the preferred remedial alternative for the reduction of TCE in the soil at SWMU 91. The ROD states, "The primary objective of this remedial action is to reduce the level of TCE-contaminated soil, thereby reducing the potential future concentrations in groundwater that could pose a threat to human health and the environment at the POE (i.e., the DOE property boundary)." The Lasagna™ system will be operated for two years in an attempt to reduce the concentration of TCE in SWMU 91 soil from an average of 84 mg/kg to an average of less than 5.6 mg/kg. If after the regulatory-approved cleanup level of 5.6 mg/kg has not been achieved after two years, the system may operate an additional 12 months to achieve the cleanup levels.

Lasagna™ uses an applied direct current electric field to drive TCE-contaminated groundwater through treatment zones installed in the contaminated soil. This induced groundwater flow is called electro-osmosis. The groundwater flow induced by the direct current travels from the anode electrodes to the cathode electrode. Groundwater containing TCE is driven away from anode electrodes toward the cathode electrode and passes through a series of iron particle treatment zones installed between them. The TCE is broken down into nonhazardous compounds as it comes in contact with the iron particles in the treatment zones. Additional information about the Lasagna™ technology and its development can be found in the *Final Soil Characterization Work Plan for the Paducah Gaseous Diffusion Plant Lasagna Pilot Test in the Cylinder Drop Test Area* (MMES 1994) and the *DNAPL Site Characterization And Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LMES 1996).

Anode electrode zones were installed generally north to south along the outer edges of the 90-ft-wide treatment area. The cathode electrode zones were

installed generally north to south in the middle of the treatment area. The direct current to energize the electrodes comes from a rectifier that is fed from a 480-volt alternating current supply constructed for this project. New overhead electrical utility lines, power transformers, electrical switching center, and associated accessories provide power to the Lasagna™ site. In general, treatment zones were installed at 5-ft intervals across the treatment area. However, treatment zones were installed at 2.5-ft intervals in higher concentration regions of the treatment area. When possible, electrode and treatment zones were installed to a depth of 45 ft. Plumbing was installed to recycle treated water from the cathode back to the anodes.

Installation of the Lasagna™ technology was completed in September 1999. The system is currently operational and is monitored for progress of remediation of SWMU 91.

Drum Mountain Removal

Removal of the portion of the Paducah Scrap Yards known as Drum Mountain was completed in September 2000 (Figure 3.2). Drum Mountain consisted of approximately 251,000 cubic feet of crushed 55-gallon ferrous metal drums that were known to be contaminated with small quantities of low-level radioactive contamination. During the accumulation of Drum Mountain, small quantities of other miscellaneous scrap metals may have been added that were believed to be similar in composition and contamination to the crushed drums. These crushed 55-gallon drums once contained UF_4, green-salt that was produced within the C-340 Reduction and Metals Building. The greensalt was emptied from the drums in the C-400 Decontamination Facility. The bulk of the greensalt was removed from the drums using a pulverizing and screening operation. Most of the empty drums were then vacuumed and washed with a solution of sodium carbonate and hot water to dislodge any remaining gross amounts of greensalt. The empty drums were crushed by a drum compactor to obtain a volume reduction of approximately seven to one. The compacted drums were then transported to the southeastern

Figure 3.2 Drum Mountain removal.

portion of the burial area now designated as SWMU 7 in the C-747-A Scrap Yard. This pile of empty, compacted drums was designated as SWMU 12.

The crushed drums were further compacted by shredding during the removal project and were packed into 160 intermodal containers to be shipped via rail to Envirocare of Utah Inc. for disposal (Figure 3.3). Sampling was conducted during the process to ensure that the material met the acceptance criteria of the disposal facility.

Removal of Drum Mountain was considered a priority because it was a potential source of surface-water contamination and because there is a burial ground beneath the site that could contribute to groundwater contamination. The

Figure 3.3 Shipment of shredded drums to Envirocare.

project was expedited, moving from public comment on the plan to completion in about a year.

Drum Mountain represented less than 10 % of the total volume of scrap metal stored at the Paducah Site. Work is tentatively scheduled to begin next year in preparation to remove the balance of the remaining scrap.

Permeable Treatment Zone

A treatability study for an injected PTZ for implementation of a small-scale PTZ in the RGA in the Southwest Plume at PGDP was initiated in 2000. The PTZ study would support the Groundwater OU decision analysis. Field installation was initiated October 31, 2000. Injection wells were installed during the fourth quarter of 2000 (Figure 3.4). The system consists of wells with approximate depth of 125 ft. into which reactive material is added that is capable of reducing the TCE and adsorbing the ^{99}Tc. A would-be monitoring system was established to evaluate the progress of the PTZ. The injection process was initiated in 2000. The method employed during 2000 was unsuccessful. A second method will be employed during 2001.

Figure 3.4 Installation of PTZ injection well.

Northwest Plume Groundwater System

The IRA of the Northwest Plume Groundwater System is documented in a ROD signed by DOE and EPA in July 1993. KDEP also concurred with the ROD. The IRA began operation August 28, 1995. The IRA consists of two extraction well fields with two wells each, transfer pipelines, a treatment system, and appurtenant equipment. The interim action is designed to contain the migration of the high-concentration zone of the groundwater contaminant plume. Plume contaminants are TCE and ^{99}Tc.

TCE is removed by an air stripping process. The TCE is volatilized by a large volume of air that comes into contact with the contaminated groundwater during the treatment process. Activated carbon filtration beds are then used to remove the TCE, which is entrained in the air stream, before the air is released to the atmosphere. ^{99}Tc is removed by an ion-exchange process.

The treatment system has extracted and treated approximately 541 million gallons of contaminated groundwater from start up through the end of 2000. The treatment system has been on-line approximately 98% of the time since startup, exceeding the goal of 85%. The IRA has consistently met the treatment goals documented in the ROD of 5 ppb TCE and 900 pCi/L of ^{99}Tc. The groundwater, after treatment, is released through a KPDES permitted outfall. Radiological emissions from this facility are discussed in Section 4.

Northeast Plume Containment System

The IRA of the Northeast Plume was documented in a ROD signed by DOE and the EPA June 1995. The KDEP accepted the ROD with the issuance of Hazardous Waste Permit Modification

8 dated June 26, 1995. The IRA system consists of an extraction well field, equalization tank, transfer pump, transfer piping and required instrumentation, electrical power and appurtenances, and use of the existing C-637-2A Cooling Tower at the PGDP for stripping of TCE. Characterization and construction activities were completed during December 1996. System startup and operational testing were conducted in February 1997 with the system fully operational by February 28, 1997. The IRA began operation February 28, 1997.

System operation includes pumping groundwater contaminated with TCE from two extraction wells to an equalization tank. A transfer pump is used to pump the contaminated water from the equalization tank through a transfer line (greater than 6,000 linear feet) to the top of the C-637-2A Cooling Tower. The cooling tower acts as an air stripper and removes the TCE from the groundwater.

Through the end of 2000, approximately 293 million gallons of contaminated groundwater have been extracted. The system has been operational approximately 95% of the time since startup with the exception during July through September 1999 when the facility was taken off-line due to cooling tower maintenance.

Decontamination and Decommissioning

D&D is conducted for facilities and other structures contaminated with radiological and hazardous material. Facilities are accepted for D&D when they are no longer required to fulfill a site mission. Legacy contamination on the structure, floors, walls, and equipment constitutes a potential for release to the environment if not appropriately managed in the near term and ultimately removed. Two major facilities comprising approximately 46,450 m^2 (500,000 ft^2) have been accepted for D&D. These facilities are the C-340 Metal Reduction Plant complex, where UF_6 was converted to uranium metal and hydrogen fluoride, and the C-410 Feed Plant complex, where uranium trioxide (UO_3) was converted to UF_6. Contaminants at these facilities include depleted uranium, natural uranium and transuranic radionuclides (at C-410 only), UF_4, PCBs, asbestos, and lead paint. Activities performed during the year include surveillance and maintenance of the structures to ensure containment of residual materials, project planning for future implementation, and planning for the additional removal and sale of surplus fluorine-generating equipment to private industry.

Technological Demonstration

The ITRD Study was conducted during 2000. The purpose of the study was to "better define the most appropriate media for the demonstration emplacement of the Deep Reactive Zone at PGDP." The treatment system was designed with a four-column configuration that would allow parallel testing of Humasorb-SC™ and iron aggregate at different flow rates of groundwater contaminated with TCE and ^{99}Tc. One pair of columns was used to test the absorption and desorption characteristics of the treatment media. A second pair of columns was used to evaluate the capacity of the two treatment media. The test system was installed in the well vault at Northwest Plume Groundwater System Extraction Well 230.

Waste Management Program

The Paducah Site Waste Management Program directs the safe treatment, storage, and disposal of waste generated before July 1, 1993 (i.e., legacy wastes), and waste from current DOE activities. The primary objective of the program is to ensure that waste materials do not migrate into the environment. Waste managed under the program is divided into the following seven categories:

- *Low-level radioactive waste* - radioactive waste not classified as high-level or transuranic and does not contain any components regulated by RCRA or TSCA.

- *Hazardous waste* - waste that contains one or more of the wastes listed under RCRA or that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity.
- *Mixed waste* - waste containing both hazardous and radioactive components. Mixed waste is subject to RCRA, which governs the hazardous components, and to additional regulations that govern the radioactive components.
- *Transuranic waste* - waste that contains more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years.
- *PCB and PCB-contaminated waste* - waste containing or contaminated with PCBs, a class of synthetic organic chemicals including 209 known isomers, each with 1 to 10 chlorine atoms on a biphenyl ring. Under TSCA regulations, PCB manufacturing was prohibited after 1978. However, continued use of PCBs is allowed provided that the use does not pose a risk to human health or the environment. Disposal of all PCB materials is regulated.
- *Asbestos waste* - asbestos-containing materials from renovation and demolition activities.
- *Sanitary/Industrial waste* - waste that is neither radioactive nor hazardous. Solid sanitary/industrial waste is basically refuse or industrial/construction debris and is disposed in landfills.
- *PCB/Radioactive Waste* - PCB waste or PCB items mixed with radioactive materials and managed as radioactive waste. PCB/radioactive/RCRA shall mean PCB/radioactive waste which may also be hazardous waste under RCRA.

Requirements for meeting waste management regulatory objectives are varied and complex because of the variety of waste streams generated by DOE activities. The goal, however, is to comply with all current regulations while planning actions to comply with anticipated future regulations.

Compliance for waste management activities involves meeting EPA and state regulations and DOE orders. In addition to compliance with these regulations, supplemental policies are enacted for management of radioactive, hazardous, PCB, PCB/rad, and mixed wastes. These policies include reducing the amount of wastes generated; characterizing and certifying waste before it is stored, processed, treated, or disposed; and pursuing volume reduction and use of on-site storage, when safe and cost effective, until a final disposal option is identified. Table 3.1 summarizes the major accomplishments of the Waste Management Program during 2000.

Pollution Prevention / Waste Minimization

The Pollution Prevention/Waste Minimization (PP/WM) Program at the Paducah Site provides guidance and objectives for minimizing waste generation. Guidance for the program comes from regulations promulgated under RCRA and the Pollution Prevention Act, as well as applicable state and EPA rules, DOE Orders, and Executive Orders.

The program is striving to meet its goals with the following strategies:

- source reduction,
- segregation,
- reuse of materials, and
- recycling.

The PP/WM Program has the following objectives:

- identify waste reduction opportunities,
- establish site-specific goals,

Table 3.1 Waste Management accomplishments during 2000

• Shipped 15 cubic meters of PCB/RCRA/ rad liquid waste to the TSCA Incinerator
• Shipped for recycling 53 cubic meters of TCE-contaminated activated carbon to Envirotral
• Shipped 0.42 cubic meters of newly generated mixed low level waste to Envirocare of Utah for treatment and disposal
• Completed the repackaging and removal of Drum Mountain
• Shipped 8.0 cubic meters of PCB Capacitors to Clean Harbors for disposal
• Shipped 39 cubic meters of PCB Capacitors to Safety Kleen for disposal
• Characterized 2,008 containers of waste under the TCLP FFCA
• Disposed 300 tons of industrial waste/construction debris in the C-746-U landfill
• Continued DMSA project and completed remediation of DMSA C-400-4
• Closed 21 PCB gasket spills and 9 PCB non-gasket spills
• Shipped 10 cubic meters of mixed low level waste to Waste Control Specialist for treatment
• Shipped 20.4 cubic meters of RCRA/rad combustible soft solid to Idaho National Engineering and Environmental Laboratory for incineration

- establish employee awareness of PP/WM principles,
- integrate PP/WM technologies into ongoing projects,
- coordinate recycling programs,
- identify PP/WM responsibilities and resource requirements, and
- track and report results.

Recycling efforts in 2000 included 3.6 metric tons (mt) (8000 pounds) of office paper, 0.10 mt (220 pounds) of aluminum cans, and dozens of printer and fax toner cartridges. Additional accomplishments of the PP/WM Program included incorporating micropurging techniques into groundwater sampling resulting in wastewater reductions; transferring unused chemicals and materials to other programs for re-use; developing a pumping/cleaning method resulting in reduction of hydrofluoric acid waste at DMSA C-400-04; reclassifying electrical equipment for disposal as non-PCB; developing screening criteria that allowed excavated material to be returned to the excavation trench instead of being handled as waste; and utilizing the direct-push method in soil sampling to minimize soil waste.

Depleted Uranium Hexafluoride Cylinder Program

DUF_6 is a product of the uranium enrichment process. A solid at ambient temperatures, DUF_6 is stored in large metal cylinders. At the end of 2000, the Paducah Site managed an inventory of 37,674 cylinders (most containing DUF_6) stored in outdoor facilities commonly referred to as "cylinder concrete or compacted gravel. The handling equipment used to stack these cylinders consists of specially designed machines that grasp and lift the cylinder with hydraulically controlled tines (Figure 3.5).

The mission of the DUF_6 Cylinder Program is to safely store the DOE-owned DUF_6 inventory until its ultimate disposition. The DUF_6 Cylinder Program Management Plan was established to meet the program mission. The plan has components such as DUF_6, cylinders, cylinder yards, cylinder-handling equipment, personnel, and financial resources. The plan has activities such as operations, management processes, and administration.

The congressional adjustment of DOE's mission from uranium enrichment to uranium inventory management (storage and utilization) has required the transformation of the previous management plan from design, construction, and operation phases to a storage or standby phase. The Program Management Plan for which DOE is responsible has been realigned to containment and use of a finite inventory of DUF_6. The various types of construction and the subsequent deterioration of the yards have led to substandard storage conditions for many of the cylinders. The variety of cylinder designs evolving over the years and various paint systems used have resulted in varying corrosion rates. These two main factors led to the need for long-term corrosion monitoring of the cylinders.

Potential risks to people and the environment posed by DUF_6 storage as it is managed are low. The DUF_6 is stored as a crystalline solid at less than atmospheric pressure. When DUF_6 is exposed to the atmosphere, hydrogen fluoride and uranium reaction products form. The uranium by-products form a hard crystalline solid, which acts as a self-sealant within the storage cylinder. The hazard potential of DUF_6 is primarily chemical toxicity from any released hydrogen fluoride, rather than a radiological hazard.

After visiting the Paducah, Portsmouth, and K-25 (currently identified as East Tennessee Technology Park) sites in 1994 and 1995, the Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 95-1 and a supporting technical report. That report addressed the improved safety of cylinders containing DUF_6.

Figure 3.5 Cylinder handler stacking DUF_6 cylinders.

Recommendation 95-1 on Depleted Uranium stated the following:

- Start an early program to renew the protective coating of cylinders containing DUF_6 from the historical production of enriched uranium.
- Explore the possibility of additional measures to protect these cylinders from the damaging effects of exposure to the elements, as well as any additional handling that may occur.
- Institute a study to determine whether a more suitable chemical form should be selected for long-term storage of the depleted uranium.

On June 29, 1995, DOE formally accepted Recommendation 95-1 and emphasized the following five focus areas for DOE response:

- Removing cylinders from ground contact and keeping cylinders from further ground contact;
- Relocating all cylinders into an adequate inspection configuration (this effort continued as new storage yards were constructed or as existing yards were refurbished);

- Repainting cylinders as needed to excessive corrosion (cylinder painting was suspended in 1999);
- Updating handling and inspection procedures and site-specific safety analysis reports; and
- Completing an ongoing study that includes an analysis of alternative chemical forms for the material (on April 15, 1999, DOE issued the *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*).

On October 16, 1995, DOE submitted an Implementation Plan that incorporated complete and near-term actions in accordance with these five focus areas. The plan also committed to managing the DUF_6 Cylinder Program using a Systems Engineering Approach. The Implementation Plan specifies the following interim and final deliverables and defines their respective content to establish an operative Systems Engineering process for the continued improvement of DUF_6 management:

- Systems Requirement Document - identifies the system requirements;
- Systems Engineering Management Plan - identifies organization, direction, and controls for system integration;
- Engineering Development Plan - identifies development actions, costs, and schedules for technical improvements;
- DUF_6 Cylinder Program Management Plan - identifies costs, schedules, and controls for operating the system and implementing required actions; and
- Approved Safety Analysis Reports - define the safety envelope.

The system includes several operational functions to maintain containment of DUF_6. These operational functions are as follows:

- Surveillance and Maintenance;
- Handling and Stacking;
- Contents Transfer; and
- Off-site Transport.

DOE is upgrading the quality of the cylinder yards to maintain the integrity of the cylinders. Fewer cylinders are stored in the refurbished yards resulting in easier access for inspections to detect corrosion or leaks. To accommodate the resulting space needs, DOE initiated construction of a new 470,000 ft^2 cylinder yard (C-745-T) which was completed during the spring of 1998. The C-745-L (south) cylinder yard was reconstructed in 2000 and covers 108,000 square feet. The design for refurbishment of more existing storage yards is complete and the reconstruction is planned for FY 2001-2004 pending funding.

In May 1997, the DOE communicated to the DNFSB that two cylinder populations needed to be painted to remain compliant with National Board Inspection Code (NBIC) "in service" pressure vessel standards. At Paducah, a population of approximately 3870 cylinders (former C-746-G yard bottom-row cylinders) were identified as requiring painting by 2010. Because it was not logical to separate the cylinders on the bottom row from the top row, it was determined that a total of approximately 7800 cylinders at Paducah would be painted. During fiscal years 1996, 1997, and 1998, a total of 3368 cylinders were painted. Cylinder painting activities at Paducah were terminated after 1998 in light of DOE's near-term plans to begin conversion of the depleted UF_6 in 2005. If conversion begins in 2005, the remaining worst case cylinders can be converted by 2010. If conversion does not become operational in 2005, alternative mitigating actions, such as restarting cylinder painting operations, will need to be implemented.

In December 1998, toxicity test results at KPDES Outfall 017 exceeded the KPDES limit for toxicity (see Section 2). Subsequent tests confirmed the toxicity exceedance and a TRE Plan was established. Zinc from cylinder painting operations was suspected as the primary cause of

the toxicity. Additional sampling and monitoring at Outfall 017 is scheduled to continue through at least May 2001. Any future cylinder painting operations at Paducah will consider the use of non-zinc based paints.

Public Awareness Program

A comprehensive community relations and public participation program on DOE activities exists at the Paducah Site. The purpose of the program is to provide the public with opportunities to become involved in decisions affecting environmental issues at the site. The program uses proactive public involvement to foster a spirit of openness and credibility among local citizens and various segments of the public.

Community/Educational Outreach

DOE and BJC Public Affairs sponsored several educational and community outreach activities during 2000, including the provision of substantial support to the completion of a new environmental study center in Ballard County. In January, the Secretary of Energy held a major invitational meeting for community leaders in Paducah, and in February, DOE Headquarters hosted a major public meeting (Figure 3.6). DOE hosted five additional public meetings during the year, including one meeting co-hosted by KDEP and EPA Region IV. At the request of host stakeholder organizations, DOE and BJC personnel participated in or supported three additional public meetings in 2000.

Earth Day

DOE, Bechtel Jacobs, and the Kentucky Department Fish and Wildlife Resources (KDFWR) jointly sponsored, planned, and implemented the 2000 Earth Day activities. The two-day event involved more than 800 sixth-grade students from area schools. A wide variety of hands-on environmental educational activities were provided, with students making decisions and taking actions on hypothetical environmental problems. The event offered an opportunity to showcase the newly opened Ballard County School District's Outdoor Environmental Study Center, which is now available to schools throughout the area.

Site Specific Advisory Board

The PGDP Citizens Advisory Board , a Site Specific Advisory Board (SSAB) chartered by DOE under the Federal Advisory Committees Act, completed its fourth full year of operation in September 2000. During the year, the Paducah SSAB held 11 regular meetings and two special-topic meetings, all open to the public and publicly noticed. The SSAB advised and made recommendations to DOE on several projects and issues, and commented on a number of documents released during the period. In 2000, the SSAB had up to 18 voting members, five *ex-officio* members, and a Deputy Designated Federal Official. The Paducah SSAB consists of individuals with diverse backgrounds and interests. It meets monthly to focus on early citizen participation in environmental cleanup priorities and related issues at the DOE facility. The Paducah SSAB participates only in activities that are governed by DOE and regulated by KDEP and EPA Region IV.

Figure 3.6 DOE hosted public meeting.

Environmental Information Center

The public has access to Administrative Records and programmatic documents at the DOE Environmental Information Center (EIC) in the West Kentucky Technology Park, 175 Freedom Boulevard, Kevil, Kentucky. In 2000, the EIC hours were changed to provide easier access. It is open Monday, Thursday, and Friday from 10 a.m. to 6 p.m., and Tuesday from Noon to 8 p.m. During the week of the second Saturday each month, the EIC is open Wednesday from 2 p.m. to 6 p.m. and Saturday from 8 a.m. to noon. During other weeks, the EIC is open Wednesday from 10 a.m. to 6 p.m. and is closed on Saturday. The phone number is 270-462-2550.

Documents for public comment are also placed in the McCracken County Public Library (formerly the Paducah Public Library), 555 Washington Street, Paducah, Kentucky. The library is open Monday through Thursday from 9 a.m. to 9 p.m., Friday and Saturday from 9 a.m. to 6 p.m., and Sunday from 1 to 6 p.m.

In 2000, an Internet web site was established for the EIC, and other public web pages related to DOE work at the PGDP were reorganized. The EIC's web page is located at www.bechteljacobs.com/p_eic/p_eic.htm.

4 Radiological Effluent Monitoring

Abstract

Radiological liquid effluent monitoring was performed at the four outfalls under the jurisdiction of DOE at the Paducah Site during 2000. Three of the four outfalls retained by DOE contain only rainfall runoff. A fourth outfall is a continuous flow outfall. The outfalls were monitored for radionuclides historically present at the site. Concentrations of the radionuclides measured (uranium and ^{99}Tc) for DOE outfalls were within acceptable limits set by DOE and by state and federal standards. The DOE-operated point sources for radionuclides in airborne effluents during 2000 were the Northwest Plume Groundwater System, the Drum Mountain Removal Project, and the C-400-04 DMSA Investigation.

Introduction

Effluents are monitored for radionuclides known to be emitted or to have been present at the site. Monitoring of radioactivity in liquid and airborne effluents is described fully in the *Paducah Site Environmental Monitoring Plan* (BJC 1999). Dose calculations are provided in Section 6.

Airborne Effluents

DOE had three sources of airborne radionuclides in 2000. The three sources were the Northwest Plume Groundwater System, the Drum Mountain Removal Project, and the C-400-04 DMSA Investigation.

Northwest Plume Groundwater System

On August 28, 1995, DOE began operation of the Northwest Plume Groundwater System. The facility is located just outside of the northwest corner of the PGDP security area. The facility consists of an air stripper to remove volatile organics from water and an ion-exchange unit for the removal of ^{99}Tc. The air stripper is located upstream of the ion- exchange unit. The ^{99}Tc concentration in the influent and effluent of the air stripper and the quantity of the water passing through the air stripper were used to calculate the total quantity of ^{99}Tc emitted from the facility in 2000.

Drum Mountain Removal Project

The ambient air was monitored as crushed UF_4 drums were removed as part of the Drum Mountain Removal Project. Small amounts of

airborne radionuclides were detected as the removal activities occurred. All analytical results were similar to background results (see Appendix C). The amount of airborne radionuclides detected were all less than state and EPA standards (Appendix E, Table 2 of 40 CFR 61).

C400-04 Department of Energy Material Storage Area Investigation

During the investigation and characterization of the C-400-04 DMSA, air from the room was exhausted through a high efficiency particulate air (HEPA) filter near the northwest corner of Building C-400. Air samples from the exhaust downstream of the HEPA filter were used to calculate the emissions from the activity.

Applicable Regulations

Effluent monitoring is to be conducted by DOE Order 5400.1, *General Environmental Protection Program*, at all DOE sites. DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, sets annual dose standards for members of the public of 10 millirems (mrem) per year from airborne releases and 100 mrem/year through all exposure pathways resulting from routine DOE operations.

Radiological airborne releases are also regulated by EPA and KDAQ under 40 CFR 61, Subpart H, which covers radionuclide emissions, other than radon, from DOE facilities. This regulation was amended in 1989 to include specific sampling requirements for each emission point with the potential to emit radionuclides resulting in an effective dose equivalent of 0.1 mrem to the most affected off-site resident. When determining potential emissions, it is assumed that air pollution abatement devices do not exist, but that the facility is otherwise operating normally.

Per 40 CFR 61 Subpart H, DOE must report radionuclide emissions by June 30 of each year to EPA via a NESHAP report. The EPA-approved methodologies for sampling and calculations must be used to address emissions.

The CERCLA ROD signed July 22, 1993, established the Northwest Plume Groundwater System. Although administrative requirements of environmental regulations need not be met for projects conducted under CERCLA, DOE has continued to supply all permit-related documentation to regulators. The Operations and Maintenance Plan approved by the EPA in March 1995 (and since revised), describes sampling and methodologies to be used at the Northwest Plume Groundwater System. The air emissions methodology is to sample the water stream before and after the air stipper. The change in contaminant concentration is used to calculate air emissions. The analysis of the water before and after the air stripper stack provides a much more accurate measure of airborne discharges than actual stack measurements due to the low, practically immeasurable radionuclide airborne effluents associated with the facility.

Airborne Effluent Results

In 2000, releases to the atmosphere from the Northwest Plume Groundwater System were calculated to be 0.00629 curies of ^{99}Tc. Estimates of airborne radionuclide emissions from the Drum Mountain Removal Project were made based on sampling data and emission factors. The estimated emissions from the project were 0.00506 curies of various radionuclides. The actual emissions were much less as shown by the ambient air monitoring data. The ambient air data collected at the Drum Mountain Removal Project showed that the amount of airborne radionuclides detected were all less than state and EPA standards Appendix E, Table 2 of 40 CFR 61. The small amount of radionuclides released by the C-400-04 DMSA Investigation, 1.36 x 10^{-9} curies of various radionuclides, were modeled to estimate the potential dose to the public. Dose to the public

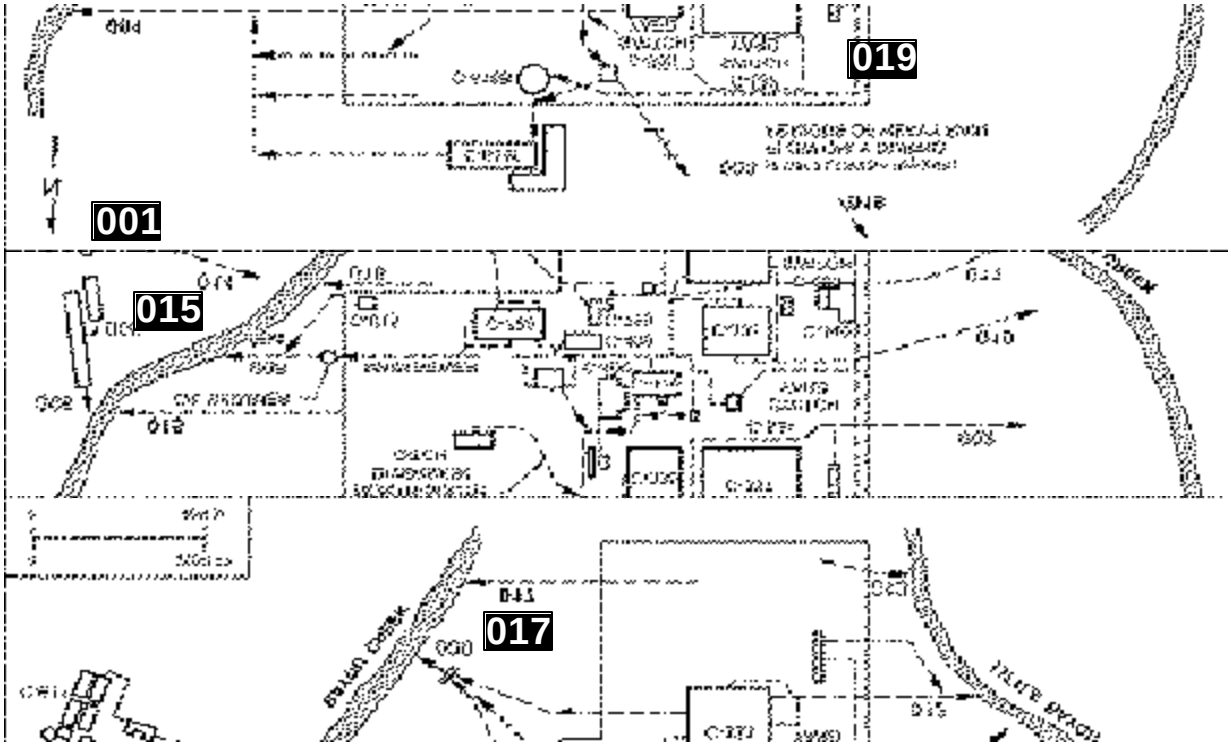


Figure 4.1 KPDES outfall locations at the Paducah Site. Outfalls 001, 015, 017, and 019 are the responsibility of DOE.

from airborne radionuclides is discussed in Section 6.

Liquid Effluents

In addition to nonradiological parameters on the KPDES permit, specific radionuclide analyses and indicator gross activity analyses are conducted on liquid effluent samples. Grab samples and composite samples at various frequencies are used to measure discharges.

DOE was responsible for a total of four outfalls in 2000 (Figure 4.1). Under KPDES permit number KY0004049, Outfall 001 is a continuous flow outfall that received discharges from USEC's Phosphate Reduction Facility, USEC's once-through cooling water, DOE's Northwest Plume Groundwater System, and DOE's Northeast Plume Containment System. In addition, surface water runoff from the northeast side of the plant also discharged into Outfall 001. Outfall 015 received surface water runoff from the east central sections of the plant. Outfall 017 received surface water runoff from the southeast section of the plant (primarily the cylinder storage yards). Outfall 019 received surface water runoff from C-746-U (DOE's operational landfill).

Applicable Regulations

The EPA safe drinking water limits for groundwater do not apply to Paducah Site surface water sampling as effluent ditches and Bayou and Little Bayou creeks are not drinking water supply sources for public or private use. However, DOE orders 5400.1 and 5400.5 establish effluent monitoring requirements to provide confidence that radiation exposure limits are not exceeded. Although no specific effluent limits for radiological parameters are included on the KPDES permit, DOE Order 5400.5 sets guidelines for allowable concentrations of radionuclides in various effluents and requires radiological monitoring to protect public health. This protection is

achieved at the Paducah Site by meeting the DOE Order 5400.5 derived concentration guidelines (DCGs), which are the concentrations of given radionuclides that would result in an effective dose equivalent of 100 mrem/year. The DCGs are based on the assumption that a member of the public has continuous, direct access to the liquid effluents, which is a conservative exposure scenario not likely to exist. Since exposure is not continuous, this results in conservatively low concenrtationfor the DCGs. Further information on DCGs is provided in Appendix A.

Liquid Effluent Monitoring Program

Sample Collection Systems

For monitoring purposes, the Paducah Site uses estimates of DCG levels and outfall flow characteristics (rainfall dependent) to determine sampling frequencies. Neither continuous monitoring nor continuous sampling are required by DOE Order 5400.5. Uranium and ^{99}Tc are the primary radionuclides of concern. Analyses are also performed for dissolved alpha, suspended alpha, dissolved beta, suspended beta, and tritium (special analysis). Data are provided in Appendix C.

Surface runoff from the closed C-746-S Residential Landfill and the C-746-T Inert Landfill is monitored quarterly. Due to their close proximity, they are monitored as one landfill (Figure 4.2). Also, surface runoff is monitored from the C-746-U Operating Contained Landfill. Surface runoff from these landfills is monitored for uranium, gross alpha, and gross beta. Grab samples are taken from the landfill runoff, the receiving ditch upstream of the runoff discharge point, and the receiving ditch downstream of the runoff discharge point. Sampling is performed to comply with KDWM permit requirements for landfill operations. The landfills will continue to be monitored for at least 30 years from the date of closure. Data are presented in Appendix C.

Liquid Effluent Monitoring Results

Tables 4.1 and 4.2 include the yearly minimum, maximum, and average concentrations of uranium and ^{99}Tc, respectively, at each outfall monitoring location. Each radionuclide is compared with the corresponding DCG and is presented as a percentage of that standard. The average concentrations at all outfalls were small percentages of the corresponding DCGs. The average concentration of uranium being discharged to Outfall 015 was 12.9% of the DCG. The average concentration of uranium being discharged to Outfalls 001, 017, and 019 was less than 3% of the DCG. Outfall 015 received runoff from the uranium burial grounds with small quantities of surface contamination from uranium compounds. That runoff is responsible for the elevated uranium concentrations associated with Outfall 015. ^{99}Tc averages for 2000 for all four outfalls were well below 1% of the 100,000 pCi/L DCG.

Data for 2000 do not show a significant change in relation to DCG levels for any radionuclide compared to data for the past five years. Figures 4.3 and 4.4 show a five-year summary of average concentrations of uranium and ^{99}Tc concentrations.

Additional data can be found in Appendix C.

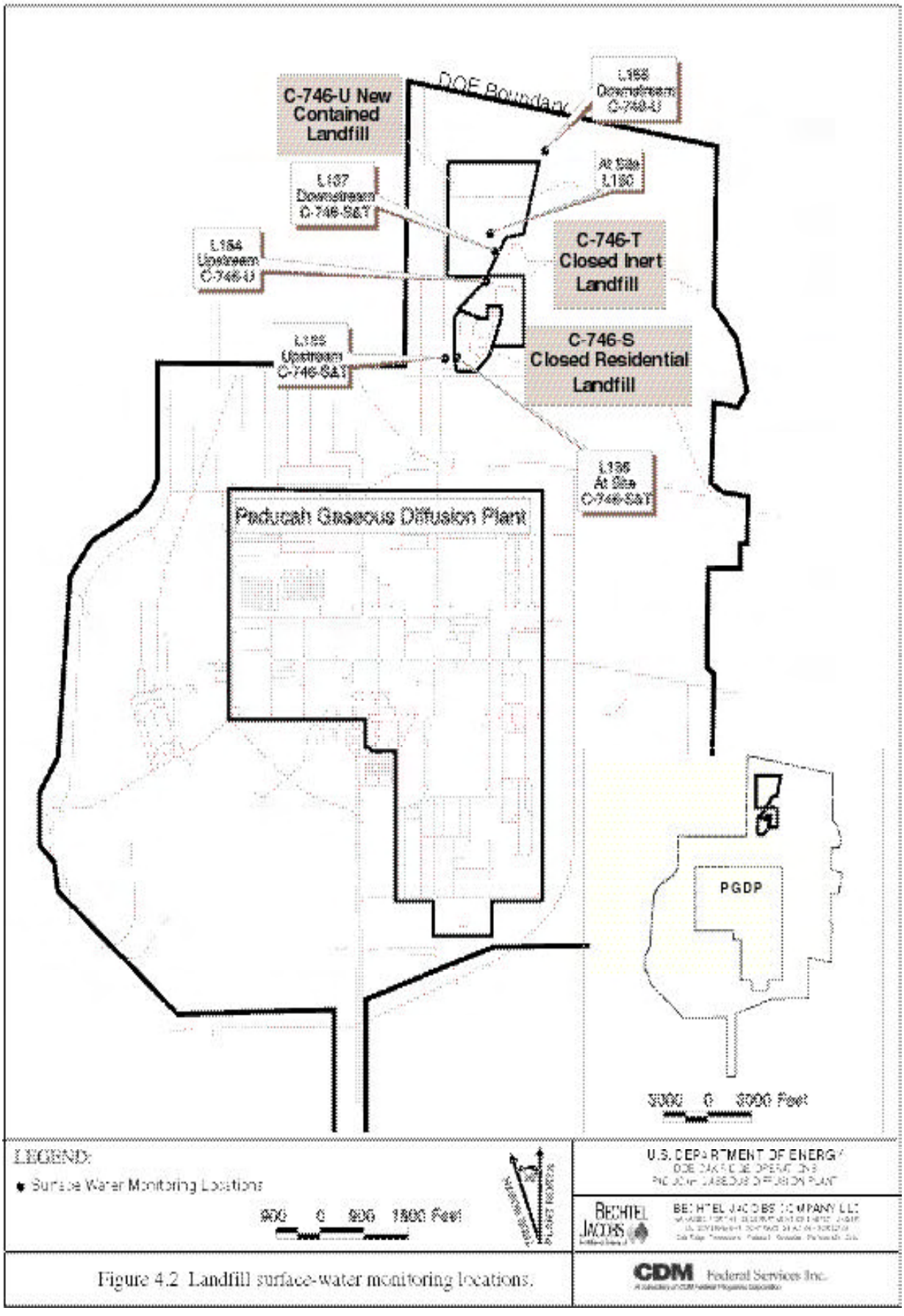


Figure 4.2 Landfill surface-water monitoring locations.

Table 4.1 Total uranium concentration in DOE outfalls for 2000

Outfall	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Average (mg/L)	Average (pCi/L)	% ^{235}U	%of DCG[a]
001	5	0.002	0.060	0.026	12.4	0.40	2.1
015	4	0.012	0.090	0.049	77.4	0.28	12.9
017	5	<0.001	<0.002	0.003	2.3	0.55[b]	0.3
019	3	<0.001	<0.001	<0.001	0.7	0.76[c]	0.1

[a] Derived Concentration Guide (DCG) for uranium is 600 pCi/L

[b] Insufficient uranium quantities to analyze for assay, assay based on past data

[c] Insufficient uranium quantities to analyze for assay, natural uranium used as assay

Table 4.2 Technetium-99 concentration in DOE outfalls for 2000

Outfall	Number of Samples	Minimum (pCi/L)[a]	Maximum (pCi/L)[a]	Average (pCi/L)	%of DCG[a]
001	6	-6	97	38	0.038
015	4	14	58	37	0.037
017	5	-12	11	3	0.003
019	1	-3	-3	-3	0

[a] DCG for ^{99}Tc is 100,000 pCi/L

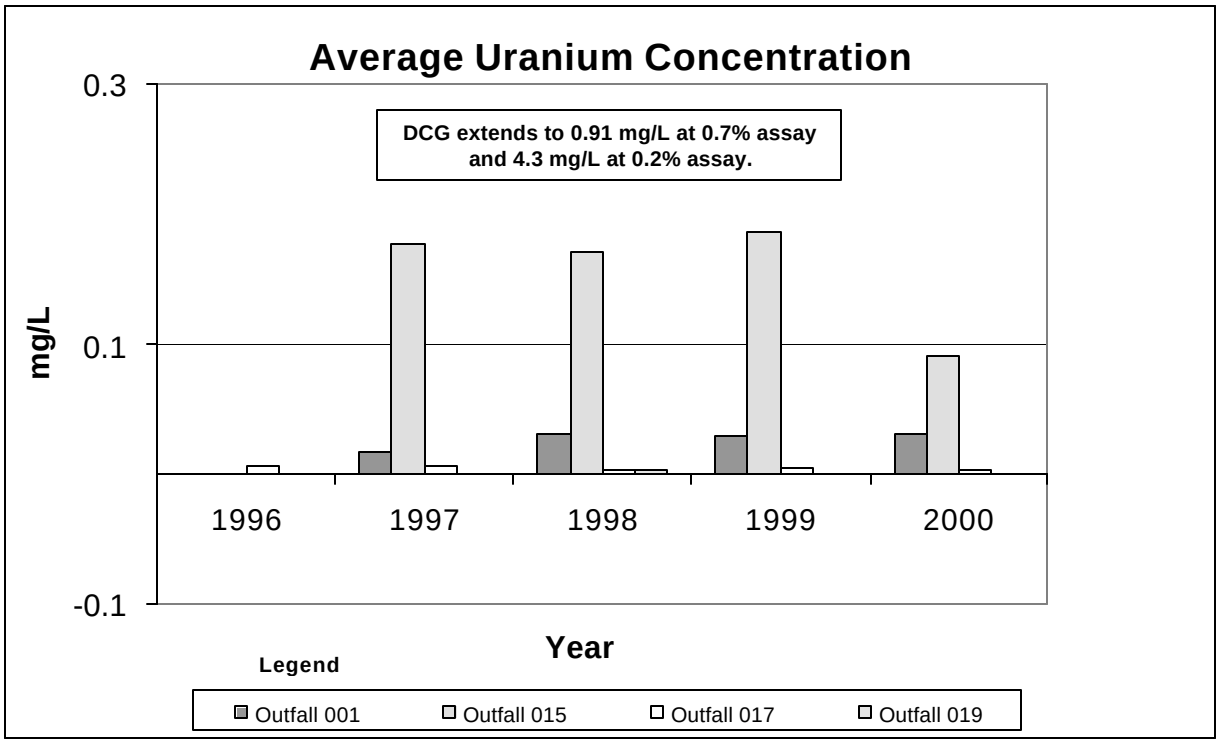


Figure 4.3 Uranium concentrations discharged to surface water, 1996 - 2000.
Note: Outfalls 001 and 015 were leased to USEC in 1996; therefore, no data are provided.
Also, DCG for ^{238}U is 600pCi/L which equates to 0.91 mg/L at 0.7% assay and 4.3 mg/L at 0.2% assay.

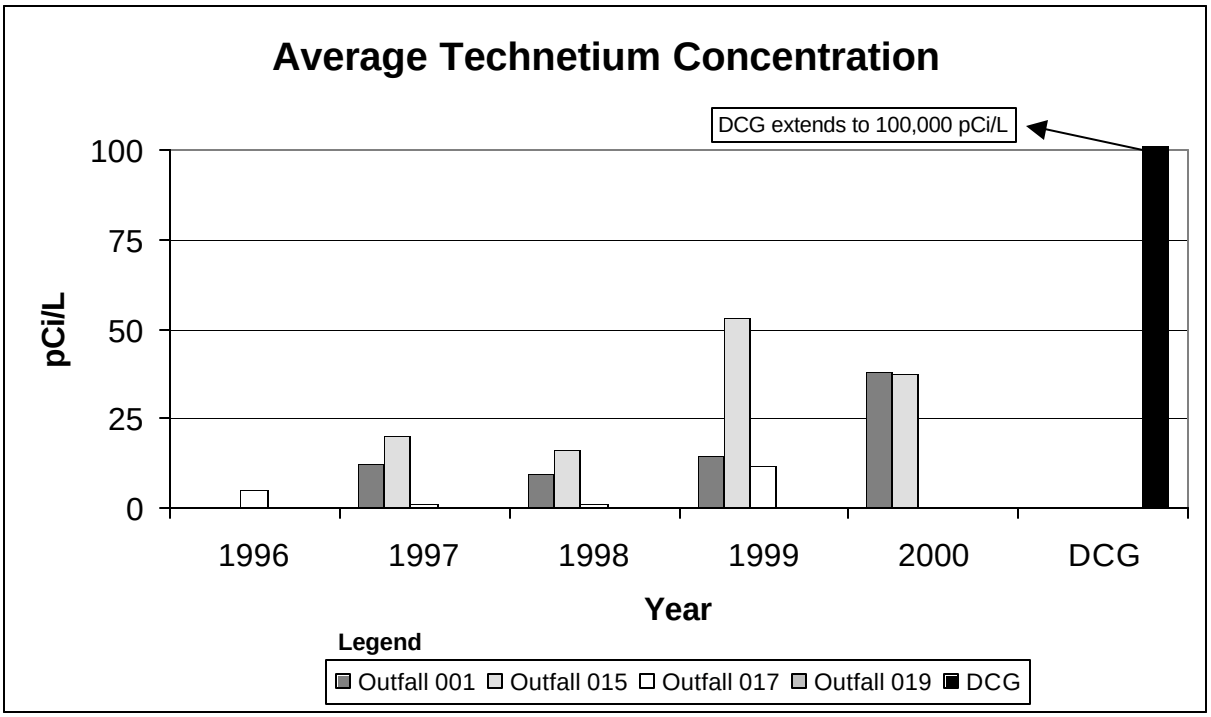


Figure 4.4 Technetium-99 concentrations discharged to surface water, 1996 - 2000.
Note: DOE assumed responsibility for outfalls 001 and 015 in 1997.

5 Radiological Environmental Surveillance

Abstract

The radiological environmental surveillance program assesses the effects of DOE activities on the surrounding population and environment. Surveillance includes analyses of surface water, groundwater (Section 9), sediment, terrestrial wildlife, direct radiation, ambient air, and in 2000, the handling and off-site shipment of a large pile of crushed UF_4 drums (Drum Mountain). Surveillance results indicate that radionuclide concentrations in sampled media were within applicable DOE standards in 2000.

Introduction

The Radiological Environmental Surveillance Program at the Paducah Site is based on DOE Orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*, which require that an environmental surveillance program be established at all DOE sites to monitor the effects, if any, of DOE activities on the surrounding population and environment. Surveillance includes analyses of surface water, groundwater (Section 9), sediment, terrestrial wildlife, direct radiation, ambient air, and in 2000, the handling and off-site shipment of a large pile of crushed UF_4 drums (Drum Mountain).

Ambient Air

Per the 1993 DOE/USEC transition, USEC is responsible for the existing radionuclide airborne point-source discharges at PGDP, with the exception of DOE's Northwest Plume Groundwater System. DOE has fugitive emission sources including piles of contaminated scrap metal, roads, and concrete rubble piles. A potential fugitive or diffuse source of radionuclides also results from the decontamination of machinery and equipment used in remediation activities, such as well drilling. The equipment is washed with high-power sprayers to remove any contaminants picked up from soil and groundwater. The concentrations of radionuclides on the equipment are so small that, under most circumstances, contamination cannot be distinguished from background.

Ambient air monitors were used around the Drum Mountain Removal Project to verify that any potential dose from radionuclide emissions were within regulatory guidelines. All radionuclide concentrations were less than the allowable regulatory concentrations (Appendix E, Table 2 of 40 CFR 61). The ratio of the measured radionuclide concentrations to the allowable concentration is tabulated in Appendix C.

DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient air data are collected at eight sites surrounding the plant in order to measure radionuclides emitted from Paducah Site sources including fugitive emissions. The Radiation/ Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services (KCHS) conducted the ambient air monitoring during 2000. The monitoring results for 2000 are listed in Appendix C. Based on these results, airborne radionuclides emitted from the Paducah Site (including both DOE and USEC emissions) were at or below background at the ambient air monitors (KCHS 2001).

Meteorological Monitoring

DOE Order 5400.1 requires that DOE facilities collect representative meteorological data in support of environmental monitoring activities. This information is essential to characterize atmospheric transport and diffusion conditions in the vicinity of the Paducah Site.

On-site meteorological data are used as input to calculate radiation dose to the public (see Section 6). Additional meteorological data from Barkley Regional Airport are used by some groups. For example, the Environmental Restoration Program uses these data to correlate precipitation with groundwater flow.

Computer-aided atmospheric dispersion modeling uses emission and meteorological data to determine the impacts of plant operations. Modeling is used to simulate the transport of air contaminants and predict the effects of abnormal airborne emissions from a given source. In addition, a multitude of emergency scenarios can be developed to estimate the effects of unplanned releases on employees and population centers downwind of the source.

Surface Water

All Paducah Site surface water runoff is released via plant outfalls either to the west to Bayou Creek or to the east to Little Bayou Creek. Bayou and Little Bayou creeks merge north of the site and discharge into the Ohio River. The net impact of the Paducah Site on surface waters can be evaluated by comparing data from samples collected upstream of the site with data from samples collected downstream of the site or from reference waterways. Bayou and Little Bayou creeks are considered to be waters of the commonwealth of Kentucky and designated for all uses by the commonwealth. However, because these creeks are not used as drinking water supplies, EPA safe drinking water standards do not apply. Radioactive effluents are controlled via DOE Order 5400.5.

Radiological sampling is conducted at upstream Bayou Creek (L1), downstream Bayou Creek (L5 and L6), downstream Little Bayou Creek (L10, L11, L12, and L241), the convergence of both creeks (L8), downstream of Outfalls 010, 011, and 013 in Little Bayou Creek (L194, L55, and L56, respectively), downstream of C-746-K Landfill in Bayou Creek (C746K-5), upstream Ohio River (L29), downstream Ohio River (L30), downstream in the Ohio River at the confluence with the Mississippi River (L306), and reference stream Massac Creek (L64). No sample point exists for upstream Little Bayou Creek as the watershed is insufficient to develop adequate flow to monitor. Nearly all water in Little Bayou Creek is comprised of discharges from plant outfalls. Therefore, background water quality for Little Bayou Creek is based on L1 (upstream Bayou Creek). L29 and L64 are reference waterways also used for comparisons with data for Little Bayou Creek surveillances. Figure 5.1 shows surveillance surface-water sampling locations, including those used only for nonradiological sampling (Section 8). Landfill surface water locations are depicted in Figure 4.2. Table 5.1 shows the surface water sampling location descriptions (surveillance and

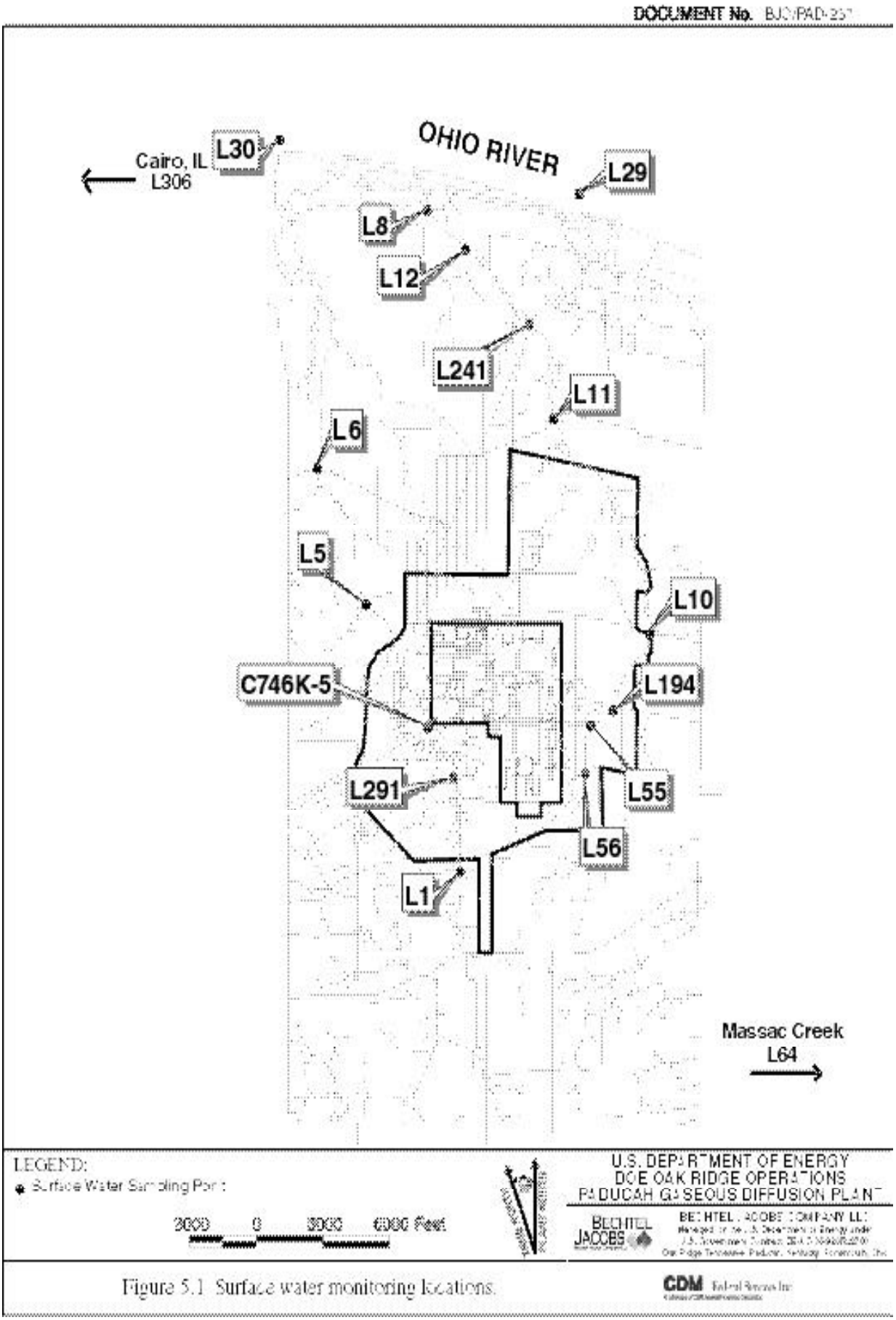


Figure 5.1 Surface water monitoring locations.

Table 5.1 Surface water sampling location descriptions

Locations	Description
L1	Upstream of plant effluents in Bayou Creek
L5	Downstream of plant effluents in Bayou Creek
L6	Downstream of plant effluents in Bayou Creek
L8	Mouth of Bayou and Little Bayou creeks
L10	Downstream of plant effluents in Little Bayou Creek
L11	Downstream of plant effluents in Little Bayou Creek
L12	Downstream of plant effluents in Little Bayou Creek
L29	Ohio River upstream of confluence with Bayou and Little Bayou creeks
L30	Ohio River downstream of confluence with Bayou and Little Bayou creeks
L55	Little Bayou Creek at confluence with Outfall 011
L56	Little Bayou Creek at confluence with Outfall 013
L64	Massac Creek background location
L135	Upstream of C-746-S&T Landfill, surface runoff
L136	At C-746-S&T Landfill, surface runoff
L137	Downstream of C-746-S&T Landfill, surface runoff
L150	At C-746-U Landfill, surface runoff
L154	Upstream of C-746-U Landfill, surface runoff
L155	Downstream of C-746-S&T Landfill, surface runoff
L194	Little Bayou Creek downstream of Outfall 010
L241	Downstream of plant effluents in Little Bayou Creek
L291	Upstream of plant effluents in Bayou Creek
L306	Ohio River at Cairo, Illinois
C-746-K-5	Bayou Creek downstream of C-746-K Landfill

Table 5.2 Routine radiological sampling parameters for surface-water surveillance for 2000

Station	Sample Type	Parameter	Frequency
L1, L5, L6, L8, L12, L55, L56, L194, L241, L291, C-746K-5, L10, L11, L29, L30, L306, L64	Grab	Dissolved alpha and beta, suspended alpha and beta, ^{237}Np, ^{239}Pu, ^{99}Tc, total U, % ^{235}U, ^{235}U, ^{238}U, ^{230}Th, ^{241}Am, ^{134}Cs, ^{137}Cs, ^{60}Co, ^{238}Pu, ^{40}K, ^{228}Th, ^{232}Th	Quarterly

compliance). Table 5.2 shows the radiological analytical parameters.

Surface Water Surveillance Results

Table 5.3 provides the average concentrations of radionuclides upstream and downstream of plant effluents in Bayou Creek and downstream of plant effluents in Little Bayou Creek. Comparisons of downstream data with upstream data and reference waterways can be made to determine the influence of plant effluents on these waterways.

The downstream Bayou and Little Bayou Creek locations show no increase in the average total uranium or uranium isotopes, although the concentrations are very small both upstream and downstream with the exception of L12, which had extremely high analytical results for uranium isotopes. This represents one sample that was most likely contaminated. No other samples at any location had results that approached the L12 concentrations for uranium isotopes.

^{99}Tc concentrations were elevated in all downstream creek locations with the exception of L11, with the highest concentrations found downstream in Little Bayou Creek. However, these concentrations are well below the plant release criteria of 900 pCi/L. ^{237}Np, ^{239}Pu, and Thorium-230 (^{230}Th) were not found in significant concentrations at any sampled location in 2000 (when compared with DCGs).

With the exception of uranium isotopes at L12, concentrations of radionuclides in effluents at the Paducah Site were far below DCGs and do not pose a health risk. DCGs are provided in Appendix B.

L55, L56, L194, and C-746-K-5 are located downstream of sections of the plant, but not below all plant influences. These locations represent individual process discharges and only small stretches of the creeks. L135, L136, L137, L150, L154, L155, are surface water runoff samples from the C-746-S, T, and U landfills (See Section 4,

Table 5.3 Routine radiological surface-water surveillance results associated with PGDP (average concentrations)

Parameter	L1 Up-stream Bayou	L5 Down-stream Bayou	L6 Down-stream Bayou	L12 Down-stream Little Bayou	Down-stream Little Bayou	L10 Down-stream Little Bayou	L11 Down-stream Little Bayou	L29 Up-stream Ohio River	L30 Down-stream Ohio River	L64 Massac Creek (Reference Waterway)	L306 Confluence of Ohio and Mississippi
Total Uranium (mg/L)	0.00	0.01	0.01	NM	NM	0.01	0.01	0.00	0.00	0.00	0.00
^{99}Tc (pCi/L)	0.59	9.8	10.2	21.4	25.0	7.76	-0.04	1.92	3.07	2.63	0.89
^{237}Np (pCi/L)	0.21	0.03	0.49	0.10	0.03	0.22	0.49	0.14	0.23	0.27	0.12
^{239}Pu (pCi/L)	0.01	0.30	0.05	-0.02	0.01	0.01	0.01	0.03	0.01	0.00	0.02
^{230}Th (pCi/L)	0.01	0.46	0.07	-0.04	0.02	0.00	0.01	0.07	0.03	0.05	0.06
^{235}U (pCi/L)	0	5.93	0	61.5	-2.38	0	0	0	0	-1.12	0
^{238}U (pCi/L)	a	a	a	5300	NM	a	a	a	a	a	a
^{234}U (pCi/L)	a	a	a	3600	NM	a	a	a	a	a	a

a = Quantities of total uranium were found to be quite small or not detected; individual isotopes of uranium were not analyzed.

NM = not measured

Figure 4.2). Data for these locations is provided in Appendix C. Individual results were compared with the DCGs provided in Appendix B and none of the DCGs were exceeded.

Sediment

Sediment is an important constituent of the aquatic environment. If a pollutant is a suspended solid or attached to suspended sediment, it can either settle to the bottom (thus creating the need for sediment sampling), be taken up by certain organisms, or become attached to plant surfaces. Pollutants in solution can adsorb on suspended organic and inorganic solids or be assimilated by plants and animals. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. Sediments play a significant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass via bottom-feeding biota to the higher trophic levels.

Sediment Surveillance Program

As a result of DOE's retaining responsibility for historic environmental issues and problems, ditch sediments are sampled semiannually through a radiological environmental surveillance program. Sediment samples were taken from 11 locations (Figure 5.2). Table 5.4 shows the radiological analytical parameters. Table 5.5 provides a brief description of each sampling location.

Sediment Surveillance Results

Table 5.6 shows the background concentrations of radionuclides in the sediments compared with concentrations downstream of all DOE outfalls for 2000. Locations S1, S2, S27, S33, and S34 are downstream of plant effluents. Locations S20, S21, and S28 are considered reference, or background sites, and can be compared with downstream data. S20 and S21, located at Bayou and Little Bayou creeks, respectively, are upstream of plant discharges, whereas S28 is located in a similar, off-site stream providing a regional reference site. S30, S31, and S32 are below certain discharges of the plant, but not below all discharges. The uranium increase seen downstream of plant discharges is attributed to plant operations.

Upstream uranium isotopes were not analyzed because not enough total uranium was found present to warrant analysis of individual isotopes. Therefore, the Bayou and Little Bayou Creek downstream concentrations are higher than the background and upstream concentrations for all uranium isotopes. This is verified by the assay values (% ^{235}U present) that historically have been lower than would be seen for naturally occurring uranium (about 0.7% assay). Table 5.7 shows no significant change in uranium concentrations in sediment over the past five years.

The Bayou and Little Bayou creeks, downstream concentrations were generally higher than the background upstream concentration for ^{99}Tc, ^{237}Np, ^{239}Pu, ^{230}Th, alpha activity, and beta acitivity. Table 5.8 shows no significant change in ^{99}Tc concentrations in sediment over the past five years. The concentration at S2 of 35.7 pCi/g in 1999 is most likely an anomaly considering the concentrations found at this location before and since. Other radionuclides, although present, are

Table 5.4 Radiological sampling parameters for semiannual sediment surveillance in 2000

Station	Parameter
S1, S2, S20, S21, S27, S28, S30, S31, S32, S33, S34	^{137}Cs, ^{40}K, ^{237}Np, ^{239}Pu, ^{99}Tc, ^{230}Th, total U, ^{234}U, ^{235}U, ^{238}U, ^{60}Co, ^{241}Am, alpha activity, beta activity

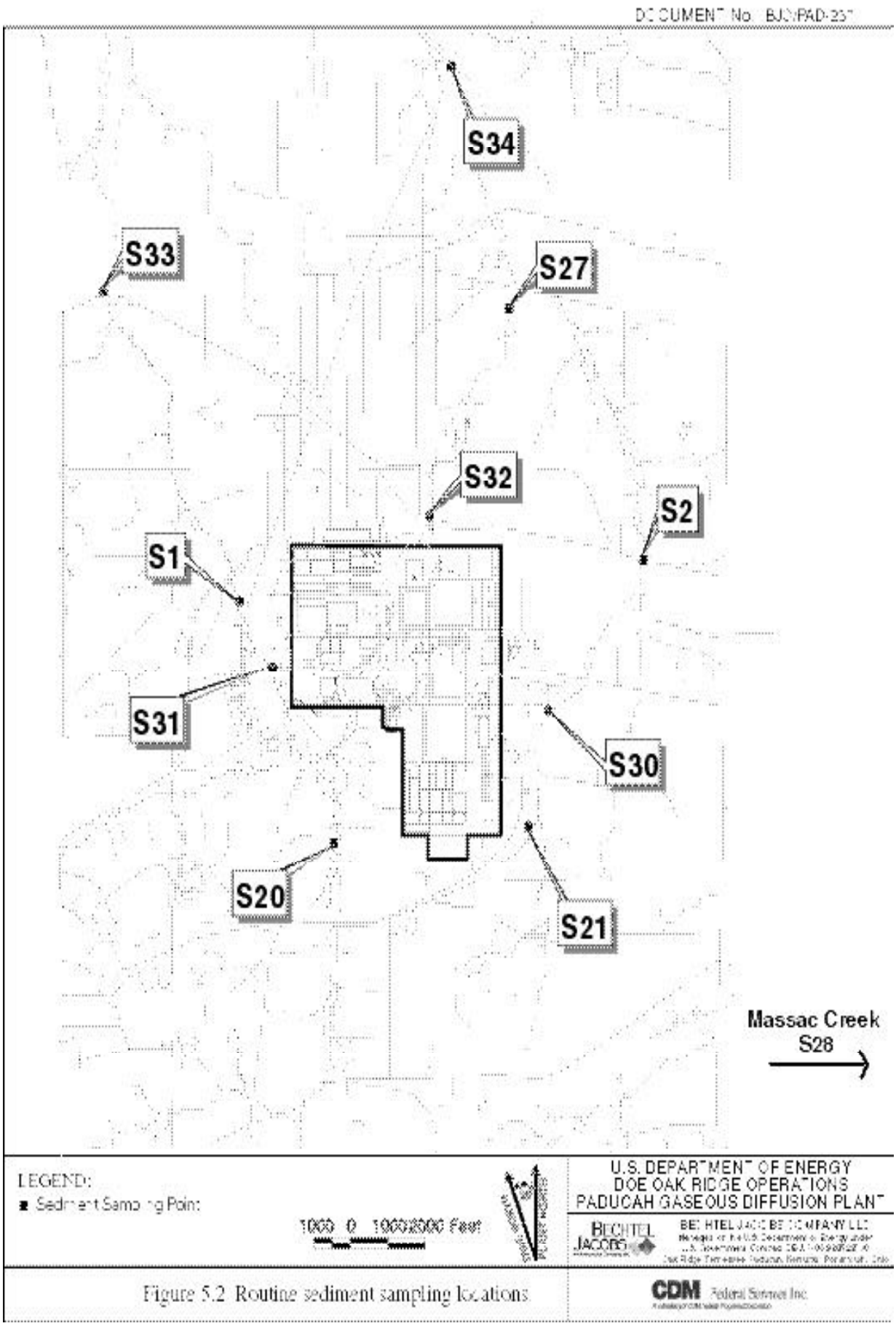


Figure 5.2 Routine sediment sampling locations

Table 5.5 Sediment sampling location descriptions

Location	Description
S1	Downstream of plant effluents in Bayou Creek
S2	Downstream of plant effluents in Little Bayou Creek
S20	Upstream of plant effluents in Bayou Creek
S21	Upstream of plant effluents in Little Bayou Creek
S27	Downstream of plant effluents in Little Bayou Creek
S28	Massac Creek Reference Stream
S30	Little Bayou Creek at KPDES Outfall 011
S31	Bayou Creek at KPDES Outfall 015
S32	Abandoned KPDES Outfall 003
S33	Downstream of plant effluents in Bayou Creek
S34	Downstream of plant effluents in Little Bayou Creek

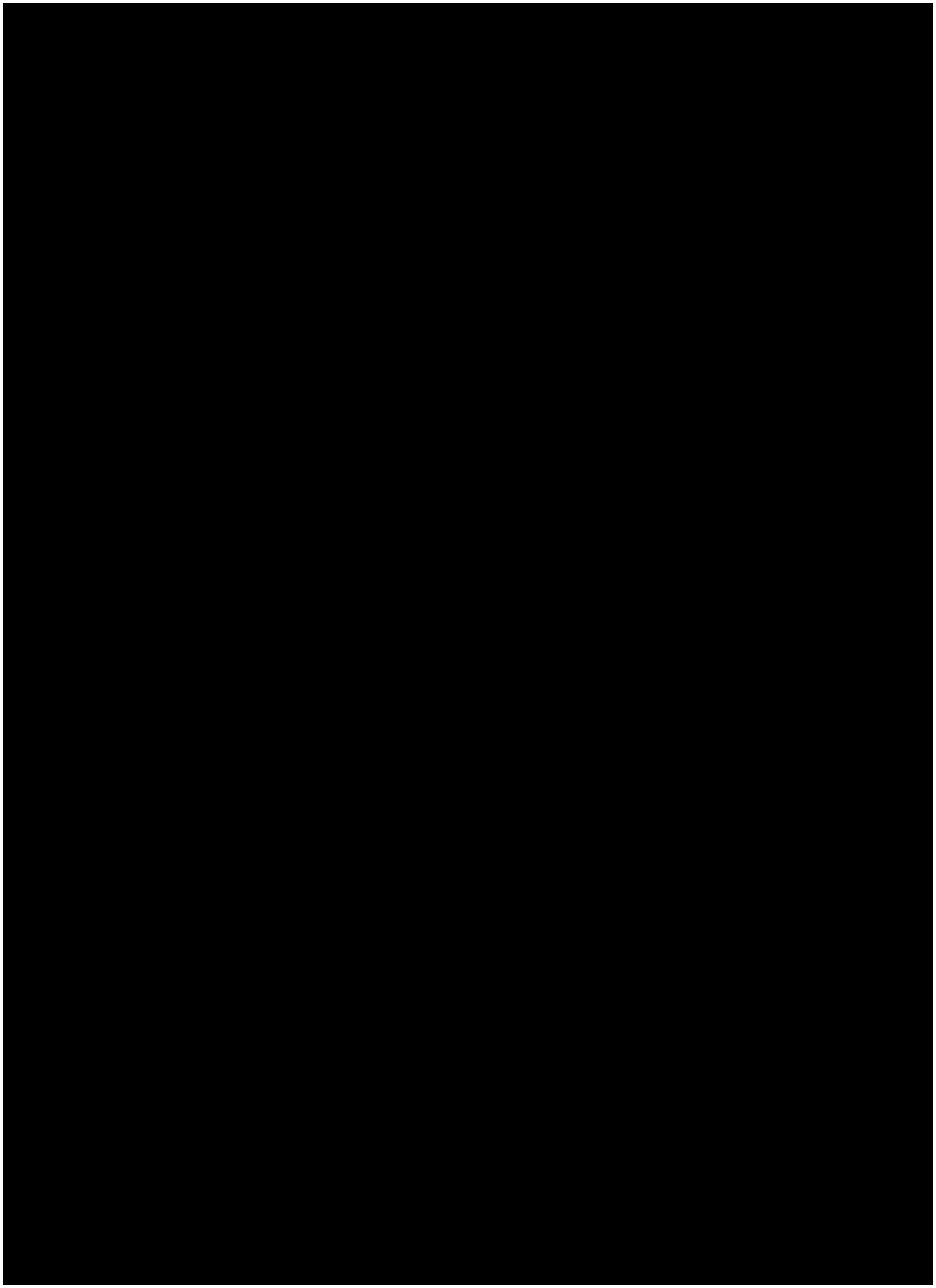


Table 5.7 Five-year uranium concentrations in sediment

	Total Uranium (µg/g)				
	1996	**1997**	**1998**	**1999**	**2000**
Upstream/Reference Locations					
			Bayou Creek		
S20	5.1	0.83	0.83	0.77	1.39
			Little Bayou Creek		
S21	2.6	2.24	2.32	0.74	2.50
			Massac Creek		
S28	1.8	0.31	0.33	0.21	2.50
Downstream Locations					
			Bayou Creek		
S1	3.5	2.59	60.1	2.56	5.35
			Little Bayou Creek		
S2	43.5	21.3	12.4	13.9	3.40
S27	10.0	10.8	2.18	10.0	8.72

Table 5.8 Five-year technetium-99 concentrations in sediment

	^{99}Tc (pCi/g)				
	1996	**1997**	**1998**	**1999**	**2000**
Reference Locations					
			Bayou Creek		
S20	0.10	0.33	0.81	ND	0.11
			Little Bayou Creek		
S21	0.11	0.22	0.45	ND	0.15
			Massac Creek		
S28	0.17	0.33	0.21	0.37	0.06
Downstream Locations					
			Bayou Creek		
S1	0.60	0.74	90.7	1.04	0.06
			Little Bayou Creek		
S2	0.51	0.62	0.59	35.7	0.10
S27	4.94	6.04	3.60	3.90	12.5

ND = Non Detect

not significantly above background values. Appendix C contains sediment data for all locations..

Terrestrial Wildlife

Annual Deer Harvest

In 2000, a total of eight deer were harvested in the WKWMA as part of DOE's ongoing effort to monitor the effects of the Paducah Site on the ecology of the surrounding area. Two deer obtained as background samples from the Ballard Wildlife Management Area (BWMA) were used for reference (Figure 5.3). Liver, muscle, and bone samples were analyzed for several radionuclides [^{137}Cs, ^{237}Np, ^{239}Pu, ^{99}Tc, ^{230}Th, ^{234}U, ^{235}U, ^{238}U, and ^{90}Sr (bone samples only)]. In addition, thyroid samples were analyzed for ^{99}Tc. Because the liver and muscle tissue are considered consumable by hunters, these tissues can be evaluated for radiological risks (dose) if analyses reveal detectable levels above background, or reference, deer. Bone and thyroid samples are used only as indicators of contamination.

In deer muscle, which is normally considered to be edible to humans, concentrations of ^{230}Th, ^{234}U, and ^{238}U were detected in both WKWMA and background deer. Background deer had the highest concentrations of ^{238}U while WKWMA deer had higher ^{234}U and ^{230}Th concentrations. Concentrations of radionuclides in the deer muscle of WKWMA deer and background deer did not vary significantly.

In deer bone, ^{230}Th, ^{234}U, and ^{238}U isotopes were found at or above detectable levels in both background and WKWMA deer. The average value of ^{230}Th seen in WKWMA deer was 0.026 pCi/g, compared to the average background deer of 0.025 pCi/g. The average ^{234}U concentration was found in WKWMA deer at 0.065 pCi/g, compared to the average ^{234}U concentration in background deer of 0.013 pCi/g. The average ^{238}U (the predominant radionuclide processed and found at PGDP) concentration was found to be 0.011 pCi/g in WKWMA deer, compared to 0.016 pCi/g in background deer.

In deer liver, ^{137}Cs, a radionuclide normally associated with fallout from nuclear weapons testing, was above detection levels in one WKWMA deer, but no background deer. ^{238}U was found only in background deer at detectable levels. ^{230}Th was detected at an average concentration of 0.148 pCi/g in WKWMA deer, compoared to 0.042 pCi/g in background deer. ^{234}U was detected in WKWMA deer at an average concentration of 0.015 pCi.g, compared to background deer at 0.157 pCi/g.

The thyroid and bone are not considered edible portions of deer, but an indicator of the presence of target radionuclides. Specifically, ^{90}Sr accumulates in the bone and ^{99}Tc accumulates to some lesser degree in the thryoid. In 2000, all results were non-detect for ^{90}Sr in the bone and ^{99}Tc in the thyroid for both WKWMA deer and background deer. Additional data are provided in Appendix C. Chapter 6 discusses dose calculations associated with eating deer from WKWMA.

Historical Deer Data Review

As a result of discussions during the Quarterly Wildlife Exchange Meeting on December 19, 2000, it was determined that data collected from deer sampled for the last 11 years should be reviewed and evaluated to identify trends. Since PCBs have only been detected in deer collected in 2000, there are not possible trends to evaluate. In 2000, PCBs were detected in fat in average concentrations of WKWMA deer at 64 µg/kg and in background deer at 23 µg/kg. Table 5.9 presents a summary of the historical data.

Metals in Deer Liver and Muscle

Lead has been detected on six occastions in both the liver and muscle (four detected results in WKWMA deer and two detected results in the background deer). Average concentrations of lead

Table 5.9a Averages of Detected Radionuclides in Deer Data from 1990 through 1995

Tissue	Analyte	Location	1990	1991	1992	1993	1994	1995
Liver	^{230}Th (pCi/kg)	WKWMA	--	--	--	--	--	--
		BWMA	--	NS	--	--	NS	--
	^{234}U (pCi/kg)	WKWMA	16	22	28	10	10	6
		BWMA	11	NS	48	12	NS	--
	^{235}U (pCi/kg)	WKWMA	5	-0.4	4	3	6	--
		BWMA	--	NS	12	--	NS	--
	^{238}U (pCi/kg)	WKWMA	3	6	4	3	19	--
		BWMA	--	NS	13	--	NS	--
Bone	^{90}Sr (pCi/kg)	WKWMA	1993	2392	--	1865	2247	1800
		BWMA	4055	NS	--	568	NS	1500
	^{234}U (pCi/kg)	WKWMA	46	16	84	--	23	16
		BWMA	18	NS	90	--	NS	19
	^{235}U (pCi/kg)	WKWMA	61	--	36	--	4	--
		BWMA	--	NS	48	--	NS	--
	^{238}U (pCi/kg)	WKWMA	114	13	24	--	9	32
		BWMA	--	NS	46	--	NS	--
Muscle	^{99}Tc (pCi/kg)	WKWMA	166	183	-146	--	-27	--
		BWMA	0	NS	-270	-307	NS	200
	^{90}Sr (pCi/kg)	WKWMA	23	--	--	--	--	--
		BWMA	26	NS	--	--	NS	--
	^{234}U (pCi/kg)	WKWMA	10	13	30	4	-6	10
		BWMA	19	NS	26	10	NS	120
	^{235}U (pCi/kg)	WKWMA	2	0	11	-1	0	--
		BWMA	7	NS	32	5	NS	24

"—" indicates Not Measured.
"NS" indicates Not Sampled.

Table 5.9b Averages of Detected Radionuclides in Deer Data from 1996 through 2000

Tissue	Analyte	Location	1996	1997	1998	1999	2000
Liver	^{230}Th (pCi/kg)	WKWMA	14	--	--	17	217
		BWMA	--	--	--	--	100
	^{234}U (pCi/kg)	WKWMA	23	--	--	--	67
		BWMA	--	--	--	--	300
	^{235}U (pCi/kg)	WKWMA	--	--	--	--	--
		BWMA	--	--	--	--	--
	^{238}U (pCi/kg)	WKWMA	7	--	--	--	--
		BWMA	--	--	--	--	43
Bone	^{90}Sr (pCi/kg)	WKWMA	1277	--	3717	3300	--
		BWMA	--	--	--	--	--
	^{234}U (pCi/kg)	WKWMA	41	--	19	36	82
		BWMA	--	--	--	--	58
	^{235}U (pCi/kg)	WKWMA	20	--	--	--	--
		BWMA	--	--	--	--	--
	^{238}U (pCi/kg)	WKWMA	8	--	--	--	52
		BWMA	--	--	--	--	--
Muscle	^{99}Tc (pCi/kg)	WKWMA	--	--	--	--	--
		BWMA	--	--	--	--	--
	^{90}Sr (pCi/kg)	WKWMA	--	--	--	--	--
		BWMA	--	--	--	--	--
	^{234}U (pCi/kg)	WKWMA	20	--	--	16	38
		BWMA	--	--	--	--	17
	^{235}U (pCi/kg)	WKWMA	--	--	--	--	--
		BWMA	--	--	--	--	--

"—" indicates Not Measured.
"NS" indicates Not Sampled.

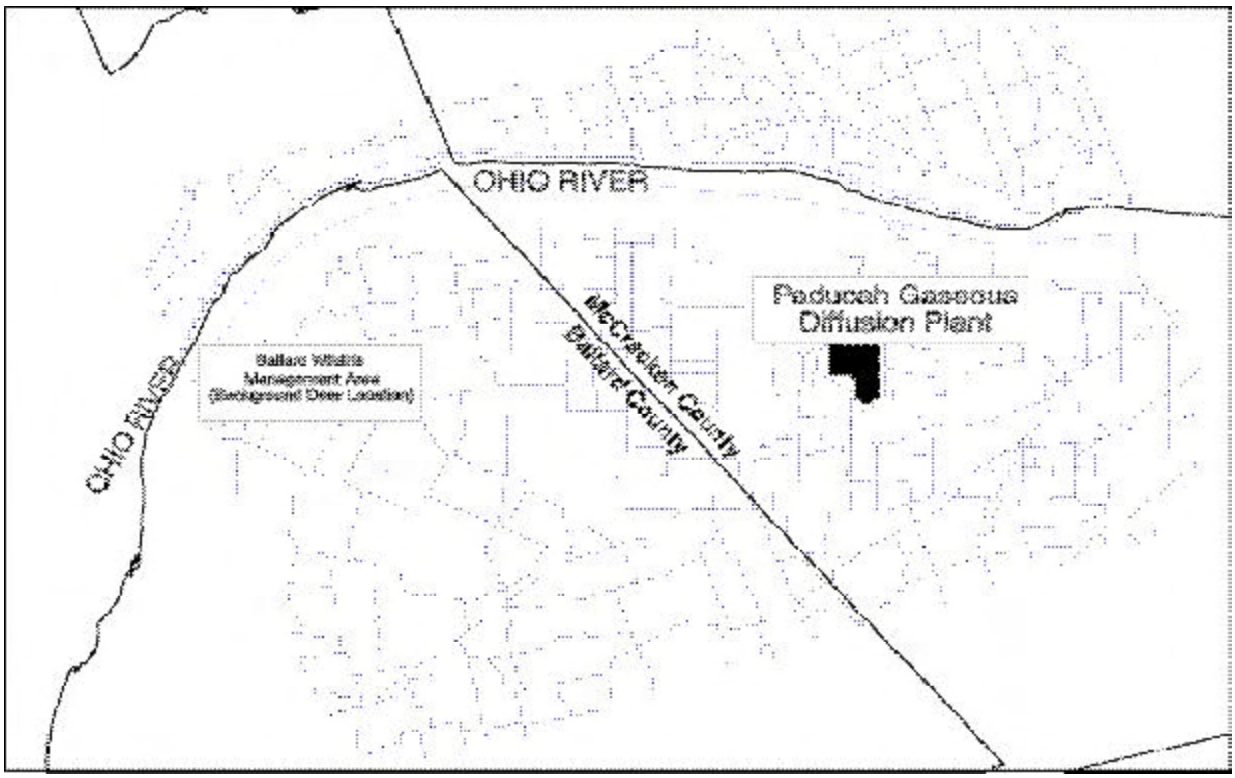


Figure 5.3 Background deer location.

were detected in deer muscle at over 455 mg/kg in 1992 and 3.3 mg/kg in liver in 1995. All other samples resulted in either non-detect or very low values.

Radiological Parameters Detected in Deer Liver

In deer liver, the highest average concentration of ^{230}Th was in 2000 in WKWMA deer at 217 pCi/kg and in background deer at 100 pCi/kg. These levels were significantly higher than the concentrations recorded in 1996 and 1999. ^{234}U has been detected at relatively low levels throughout the years in the WKWMA and background deer. The highest average concentration of 67 pCi/kg in WKWMA deer was recorded in 2000 at the Paducah Site, with a much higher single concentration of 300 pCi/kg being detected in 2000 at the background location. For ^{238}U, average concentrations in WKWMA deer have been generally decreasing while the background deer concentrations (detected at 43 pCi/kg) were highest in 2000. ^{235}U average concentrations have been generally decreasing for both WKWMA and background deer; the highest average concentration was detected in background deer at 12 pCi/kg.

Radiological Parameters Detected in Deer Bone

While average concentrations of ^{90}Sr in the bone of background deer have been generally decreasing the last 11 years, concentrations in WKWMA deer remain elevated. The highest average concentration of ^{90}Sr in WKWMA deer was detected in 1999 at 3300 pCi/kg and in background deer in 1990 at 4055 pCi/kg. ^{234}U concentrations in deer have gone up and down since 1990, with the average concentrations in 2000 being the second highest levels recorded for both the WKWMA deer at 82 pCi/kg and background deer at 58 pCi/kg. ^{235}U concentrations in WKWMA deer have been decreasing, with no detections in the last four years. The highest average concentration of ^{235}U was 61 pCi/kg, recorded in 1990 in WKWMA deer. ^{238}U has gone up and down since 1990, with an average

concentration of 52 pCi/kg in 2000 in WKWMA deer being the second highest recorded. The highest average concentration in ^{238}U of 114 pCi/kg was recorded in 1990 in WKWMA deer.

Radiological Parameters Detected in Deer Muscle

^{99}Tc was detected in 1990 and 1991 in the muscle of WKWMA and background deer. ^{99}Tc has not been detected in WKWMA deer since 1991 and in background deer since 1995. The highest average concentration of ^{99}Tc was 200 pCi/kg, recorded in 1995 in background deer. ^{90}Sr was detected in 1990 for both the WKWMA and background sites and since that time has not been detected. ^{234}U concentrations have gone up and down since 1990 for both the WKWMA deer and background deer. Slightly elevated concentrations were recorded for both sites in 2000. The highest average concentration of 120 pCi/kg was recorded in 1995 for background deer. Concentrations of ^{235}U have been non-detect in WKWMA deer since 1993, while background concentrations have been non-detect since 1996.

Summary

In general, no specific trends were identified in WKWMA or background deer in metals or radiological parameters. Additional data collected each year will be added to the trending analysis to help identify possible trends. See Section 6 for dose calculations and discussion associated with deer consumption.

Direct Radiation

A primary pathway of concern for DOE's operations at the Paducah Site is direct external radiation exposure. External radiation exposure is defined as exposure attributed to radioactive sources outside the body (e.g., cosmic gamma radiation). Sources of external radiation exposure from the Paducah Site include cylinder storage yards, the cascade system, and small sources such as instrument check locations. Cylinder storage yards have the largest potential for a dose to the public because of their proximity to the PGDP security fence.

The *Paducah Site Environmental Monitoring Plan* (BJC 2000b) establishes DOE's program for monitoring external gamma radiation at areas accessible to members of the public. The External Radiation Exposure Monitoring Program has the following three objectives:

- to establish the potential radiation dose received by a member of the public from direct exposure to DOE operations at the boundary of the DOE perimeter fence,
- to establish the potential dose a member of the public may receive visiting or passing through accessible portions of the DOE reservation, and
- to calculate the radiation dose equivalent to the maximally exposed individual member of the public.

In 2000, monitoring consisted of quarterly placement, collection, and analysis of environmental thermoluminescent dosimeters (TLDs). TLD locations are shown in Figure 5.4. Monitoring results indicate that five locations were consistently above background levels (BJC 2001a). Four of these locations were all at or near the PGDP security fence in the vicinity of UF_6 cylinder storage yards and one was outside the security fence west of the Lasagna ™ Treatment Site and near the C-745-B Cylinder Yard (Figure 5.5).

Annual dose rates for the background locations and the five locations above background were calculated. The mean annual background exposure was determined to be 105 milliRoentgen (mR). For each location, the mean background

exposure was subtracted from the annualized total exposure to obtain a net annual exposure. The net annual exposure represents the total exposure at that location, for the entire calendar year 2000, attributed to the Paducah Site (Table 5.10). Exposure measured at these locations is assumed to result from DOE operations. Dose from direct radiation exposure is discussed in Section 6. Additional data are provided in Appendix C.

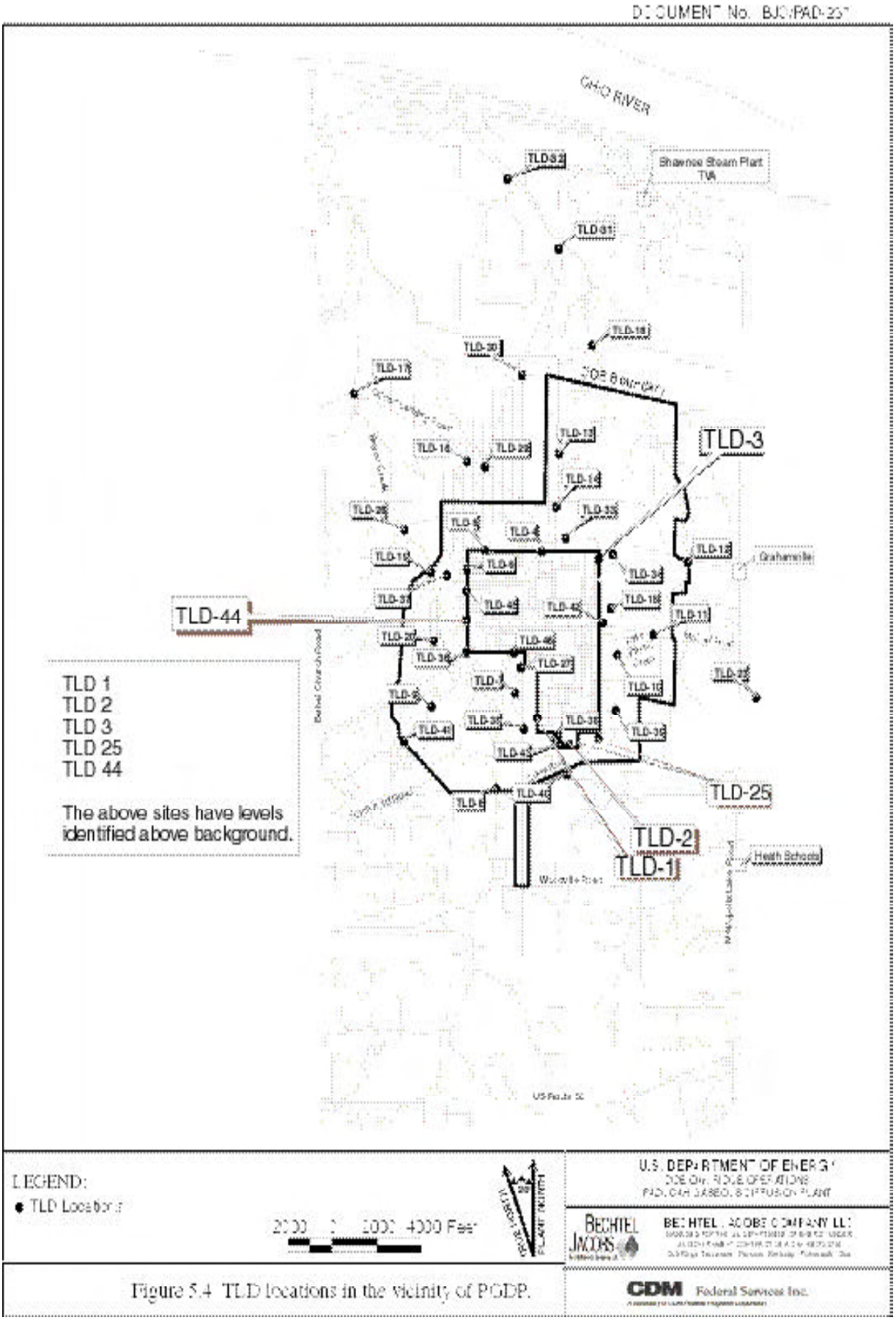


Figure 5.4 TLD locations in the vicinity of PGDP.

Figure 5.5 Uranium hexafluoride cylinder storage yard.

Table 5.10 Net annual exposure from direct radiation attributed to the Paducah Site for 2000 (mR)

Location	TLD-1	TLD-2	TLD-3	TLD-25	TLD-44
total annual exposure	424	751	470	121	184
background	105	105	105	105	105
net annual exposure	319	646	365	16	79

6 Dose

Abstract

For 2000, exposure pathways potentially contributing to dose were determined to include ingestion of surface water, ingestion of sediments, ingestion of deer meat, direct radiation, and atmospheric releases. The highest estimated dose a maximally exposed individual might have received from all combined DOE exposure pathways (worst-case scenario) was 1.9 mrem. This dose is less than 2% of the applicable federal standard of 100 mrem/year.

Introduction

This section presents the calculated doses to individuals and the surrounding population from atmospheric and liquid releases from the Paducah Site, as well as direct radiation (sections 4 and 5). In addition, potential doses from special case exposure scenarios, such as deer meat consumption, were calculated based upon deer sample analyses. Doses from naturally occurring sources are discussed in Appendix A.

DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, limits the dose to members of the public to less than 100 mrem/year total effective dose equivalent from all pathways resulting from operation of a DOE facility. Information on the demography and land use of the area surrounding the plant and identification of on-site sources have indicated certain radionuclides and exposure pathways. In practice, only a few pathways constitute the major sources of exposure in any given situation.

For the Phase I Remedial Action Site Investigation, a preliminary assessment of risk to the health of the public from contaminants at the Paducah Site was conducted. This study identified the following four primary pathways that each could contribute greater than 1% to the total off-site dose: (1) groundwater ingestion, (2) sediment ingestion, (3) wildlife ingestion, and (4) exposure to direct radiation. Since that preliminary assessment, groundwater wells that supplied drinking water in the downgradient direction from the PGDP have been sealed to prevent use, resulting in a loss of that pathway. In addition, the Northwest Plume Groundwater System began operation in 1995, resulting in an airborne pathway now included in the dose calculations. In 2000, the Drum Mountain Removal Project and the C-400-04 DMSA Investigations also added to the airborne dose. Furthermore, in 1999, a drinking water pathway was added for consumption of surface water at the nearest public drinking water source (Ohio River at Cairo, Illinois).

To fully assess the potential dose to the public, a hypothetical group of extreme characteristics was used to postulate an upper limit

to the dose of any real group. This is referred to as the worst-case scenario. Actual dose received is likely to be considerably less than the dose calculated for the worst-case scenario.

Terminology and Internal Dose Factors

Most consequences associated with radionuclides released to the environment are caused by interactions between human tissue and various types of radiation emitted by the radionuclides. These interactions involve the transfer of energy from radiation to tissue, possibly resulting in tissue damage. Radiation may come from radionuclides outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin). Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides inside the body are called internal exposures. This distinction is important because external exposure occurs only as long as a person is near the external radionuclide; simply leaving the area of the source will stop the exposure. Internal exposure continues as long as the radionuclide remains inside the body.

A number of specialized units have been defined for characterizing exposures to radiation as defined in Appendix A. Because the damage associated with such exposures results primarily from the deposition of radiant energy in tissue, the units are defined in terms of the amount of incident radiant energy absorbed by tissue and of the biological consequences of that absorbed energy. These units include the following:

- *Committed effective dose equivalent (CEDE)* — the total internal dose (measured in mrem) received over a 50-year period resulting from the intake of radionuclides in a one-year period. The CEDE is the product of the annual intake (pCi) and the dose conversion factor for each radionuclide (mrem/pCi).

- *Effective dose equivalent* — includes the CEDE from internal deposition of radionuclides and the dose from penetrating radiation from sources external to the body. This is a risk-equivalent value and can be used to estimate the health-effects risk to the exposed individual.

- *Total effective dose equivalent* — includes the sum of the effective dose equivalent (for external exposures) and the CEDE (for internal exposures). For purposes of compliance, dose equivalent to the whole body may be used as the effective dose equivalent for external exposures.

Internal dose factors for several radionuclides of interest at the Paducah Site are included in Appendix A.

Direct Radiation

In 2000, DOE conducted continuous monitoring for direct external radiation exposure (Section 5). The monitoring results indicate that, due to inaccessibility of the public to radioactive source areas, the dose to the maximally exposed individual member of the public (i.e., the neighbor living closest to the PGDP security fence, shown in figure 6.1) from DOE operations did not vary statistically from background (i.e., essentially zero) (BJC 2001a).

For purposes of this ASER, an additional potential receptor was considered. This receptor is assumed to frequently travel along Dykes Road in the vicinity of location TLD-25 (Figure 5.4). A very conservative exposure scenario assumes occupancy for the maximally exposed receptor at this location in 2000 to be 100 hours based on an individual driving past this location twice per day at 12 minutes per trip, five days per week, 50 weeks per year. The mean dose rate for location TLD-25, attributable to the Paducah Site, was determined to be 0.0017 mrem/hour (BJC 2000a). Therefore, the

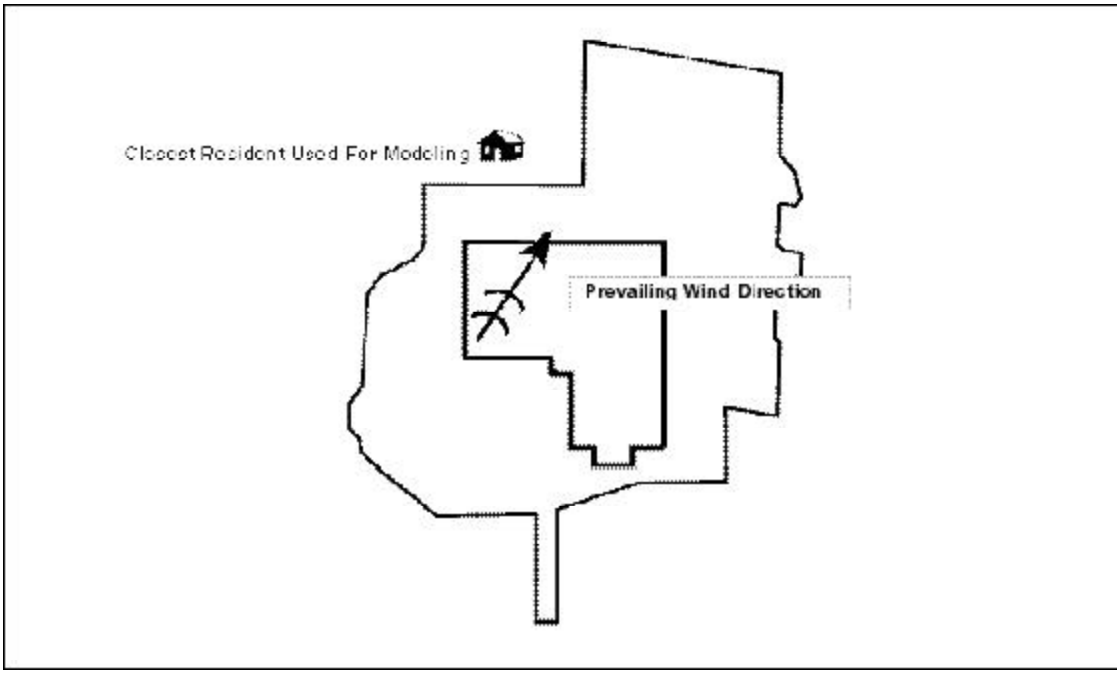


Figure 6.1 Closest resident used for modeling.

dose to this receptor is calculated at 0.17 mrem for 2000. It is worth noting that actual occupancy at this location is probably much less than assumed since any shielding from the receptor's vehicle is not considered. Furthermore, even if the receptor were assumed to have occupied this site for 365 days, 24 hours per day in 2000, the total dose received would have been approximately 15 mrem, well below the DOE 100 mrem limit to the public.

Surface Water

The most common surface-water pathway for exposure is through drinking water containing radionuclides. A drinking water pathway dose was calculated for an individual assumed to consume water from the public drinking water supply at Cairo, Illinois. Cairo is the closest drinking water system that uses water downstream of PGDP effluents. Maximum stream concentrations of ^{99}Tc and uranium radionuclides were measured in Bayou and Little Bayou creeks and, using dilution factors based on U. S. Geological Survey flow measurements, were used to calculate approximate radionuclide concentrations at the Cairo water intake. The additive dose from both creeks to the Cairo water system would have resulted for ^{99}Tc and uranium in a dose to an individual user of approximately 0.00055 mrem in 2000. This is a statistically insignificant dose; therefore, the surface-water pathway is not considered a significant contributor to the dose received by the maximally exposed individual from DOE sources at PGDP.

Contaminated Sediment

Exposure to contaminated sediment in Bayou and Little Bayou creeks could occur during fishing, hunting, or other recreational activities. Exposure is possible through incidental ingestion of contaminated sediment. The worst-case ingestion assumption is that an individual would splash around in one of the creeks every other day during the hunting season and ingest a small amount of sediment each visit (50 mg/day). A dose is then calculated based on the radionuclide concentrations (Section 5, Table 5.6) and amount of exposure via ingestion. Upstream samples are assumed to be background and are subtracted from downstream sample results to arrive at a dose associated with site releases. The downstream location with the maximum dose is assumed to

represent the dose received from this pathway by the maximally exposed individual.

Doses are calculated for ingestion of sediments for both Bayou and Little Bayou creeks. For Little Bayou Creek, the worst-case dose was calculated at S27. For Bayou Creek, the worst-case dose was calculated at S1. The worst-case dose for Little Bayou Creek exceeds that for Bayou Creek. Therefore, the estimated worst-case dose above background from sediment ingestion that would have been received by an individual who was assumed to spend time in the WKWMA every other day during the hunting season would be 0.032 mrem in 2000. Sediment sample locations are shown in Figure 5.2. Dose calculations are provided in Appendix B.

Ingestion of Deer

The effect of an intake of a radionuclide by ingestion depends on the concentration of the radionuclide in food and drinking water and on the individual's consumption patterns. The estimated intake of a radionuclide is multiplied by the appropriate ingestion dose factor to provide the estimate of CEDE resulting from the intake.

Terrestrial wildlife, such as deer, can come into contact with contaminated soil, ingest plants that have taken up contaminants, or ingest contaminated water. Hunting is permitted in the WKWMA surrounding the Paducah Site, and the limit for deer harvest is two deer per person per season. Approximately 100 deer are harvested per year from WKWMA. The Paducah Site dose calculations assume that an individual kills two average-weight deer and consumes the edible portions of those deer during the year (approximately 100 pounds of meat and five pounds of liver). The dose is calculated for each deer.

In 2000, eight deer from the Paducah Site were sampled along with two reference deer from the BWMA (Section 5). As a worst-case scenario for site dose contribution, it is assumed that a person kills and eats the two deer with the largest dose potential. The worst-case dose was calculated to be 4.9 mrem, which is 1.7 mrem above the average dose from all background deer (Hampshire 2000). Therefore, 1.7 mrem is used in the worst case scenario calculations.

Airborne Radionuclides

DOE's radionuclide airborne point-sources that contributed to the public dose in 2000 included three sources. These sources were the Northwest Plume Groundwater System, the Drum Mountain Removal Project, and the C-400-04 DMSA Investigation. These point-sources are discussed in Section 4. These point-sources were monitored to determine the extent to which the general public could be exposed and to demonstrate compliance with EPA regulations that are based on International Commission on Radiological Protection (ICRP) publications (ICRP 1980).

The 50-year CEDE (internal) from DOE air sources to the maximally exposed individual, who under most circumstances is the person living closest to the plant in the predominant wind direction, is calculated each year. EPA-supplied CAP-88 software was used to calculate the off-site dose from PGDP air emissions. CAP-88 provides a framework for developing dose and risk assessments for the purpose of demonstrating compliance with 40 CFR 61.93(a). CAP-88 assesses both collective populations and maximally-exposed individuals. The dose for the three projects to the maximally exposed individual from radioactive emissions was calculated to be 1.1×10^{-3} from the Northwest Plume Groundwater System; 7.7×10^{-3} from the Drum Mountain Removal Project; and 1.0×10^{-9} from the C-400-04 DMSA Investigation. If one individual were to receive the maximum dose from each of these three sources, it would add up to approximately 8.8×10^{-3} (0.0088) mrem which is well below the 10 mrem limit of 40 CFR Part 61, Subpart H. The maximally exposed individual for the three projects would be located 1220 m (4000 ft) north of the plant.

Conclusions

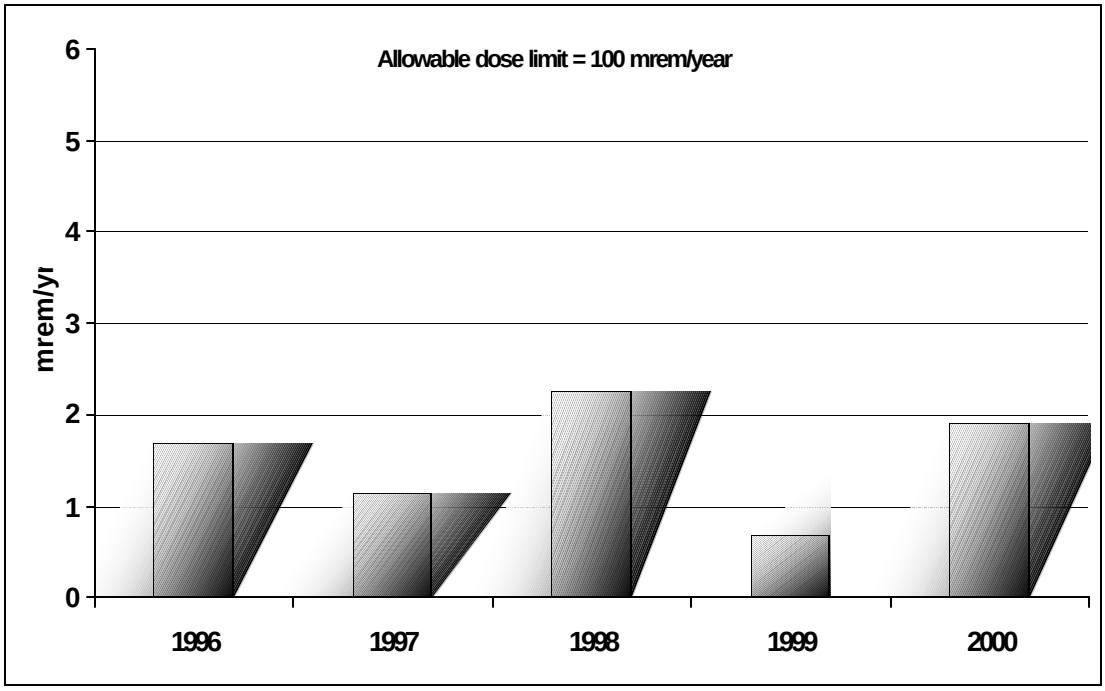
Table 6.1 provides a summary of the dose for 2000 from the Paducah Site that could be received by a member of the public assuming worst-case exposure from all major pathways. The largest contributor to the calculated dose is from ingestion of deer meat. The groundwater pathway from DOE sources is assumed to contribute no dose to the population because all residents have been supplied with public water by DOE. The worst-case combined (internal and external) dose to an individual member of the public was calculated at 1.9 mrem. This level is well below the DOE annual dose limit of 100 mrem/year to members of the public and below the EPA limit of 10 mrem airborne dose to the public.

Estimates of radiation doses presented in this report were calculated using the dose factors provided by DOE and EPA guidance documents. These dose factors are based on International Commission on Radiological Protection Publication 30 (ICRP 1980). Figure 6.2 shows the potential (worst-case) annual dose as calculated for the past five years.

Table 6.1 Summary of potential radiological dose from the Paducah Site for 2000 (worst-case combined exposure pathways)

	Dose (mrem/year)	Percent of total
Ingestion of surface water	0.00055	<1
Ingestion of sediments	0.032	2
Ingestion of deer meat	1.7	89
Direct radiation	0.17	9
Atmospheric releases	0.0088	1
Total annual dose above background (all pathways)	**1.9[a]**	**100**

[a] = Maximum allowable exposure is 100 mrem/year (DOE Order 5400.5)


Allowable dose limit = 100 mrem/year
mrem/yr
6
5
4
3
2
1
0
1996
1997
1998
1999
2000

7 Nonradiological Effluent Monitoring

Abstract

Effluents are gaseous or liquid waste discharges to the environment. Monitoring effluents assures compliance with applicable release standards established by federal and state regulations. Effluent monitoring consists of the collection and analysis of samples or measurements of liquid, gaseous, or airborne effluents. The monitoring determines and quantifies contaminants and process-stream characteristics, assesses any chemical or radiological exposures to members of the public or the environment, and demonstrates compliance with applicable standards. Monitoring effluents is necessary to determine the effects emissions may have on the public and the surrounding environment.

In 2000, there were two KPDES outfalls at the Paducah Site that experienced exceedences for toxicity. Outfalls 001 and 017 exceeded reportable KPDES effluent discharge permit limits for acute toxicity and chronic toxicity, respectively. No NOVs were issued in 2000 for exceedences.

In 2000, DOE had two point sources and several fugitive sources for nonradiological air emissions. The combined emissions from these DOE sources were small; therefore, the Paducah Site is considered a minor source in accordance with the CAA.

Introduction

Responsibility for nearly all nonradioactive airborne emission sources at the PGDP was turned over to USEC as a result of the 1993 lease agreement between USEC and DOE. Only a few fugitive sources such as gravel roads, dirt piles (resulting from construction excavation), metal scrap pile windage, and two point sources remained the responsibility of DOE in 2000. The small amount of emissions from DOE sources results in CAA classification of the Paducah Site as a minor air emissions source.

Monitoring of nonradiological parameters in liquid effluents is summarized in the *Paducah Site Environmental Monitoring Plan* (BJC 2000b) and is based on KPDES Permit KY0004049, and KDWM landfill permits 073-00014, 073-00015, and 073-00045. Effluents are monitored for nonradiological parameters listed on the permit governing the discharge.

Airborne Effluents

Airborne Effluent Applicable Regulations

The CAA at the Paducah Site is administered by KDAQ. DOE has responsibility only for air emission sources under DOE program control; therefore, this report does not address emissions from the PGDP sources leased to USEC.

Airborne Effluent Monitoring Program

The point sources of air emissions other than radionuclides (Section 5) for the Paducah Site in 2000 were the Northwest Plume Groundwater System and the Northeast Plume Containment System. These systems combined removed 2480 pounds (1.25 tons or 205 gallons) of TCE, which is a volatile organic compound (VOC), from the groundwater. These facilities remove TCE contamination from the groundwater by air stripping. At the Northwest Plume Groundwater System, TCE-laden air passes through carbon filtration removing much of the TCE. The air stream is then released to the atmosphere where the remaining TCE naturally breaks down.

The CAA defines VOC emissions as criteria pollutants. A minor source is limited to 100 tons per year of each criteria pollutant. If greater quantities of criteria pollutants are emitted, then the source is classified as a major source. A minor source has less stringent permit requirements because of the reduced potential for health effects from the smaller amount of emissions.

The CAA also limits the emissions from a minor source of HAPs to 10 tons/year for each individual pollutant and 25 tons/year for all HAPs combined. TCE is a HAP. The amount of HAP emitted in 2000 was less than the 2480 pounds (1.25 tons or 205 gallons) of TCE removed from the groundwater from the combination of the Northwest Plume Groundwater System and the Northeast Plume Containment System.

Liquid Effluents

Liquid Effluent Applicable Regulations

The CWA for the Paducah site is administered by KDOW through the KPDES Wastewater Discharge Permitting Program. The sitewide KPDES permit (KY0004049) became effective April 1, 1998, and expires March 31, 2003. This permit contains limits based on water quality criteria for a zero-flow receiving stream.

KDWM specifies in landfill permits 073-00014, 073-00015, and 073-00045 that surface runoff be analyzed to ensure that landfill constituents are not discharging into nearby receiving streams.

Liquid Effluent Monitoring Program

DOE conducts nonradiological effluent monitoring for outfalls under its jurisdiction (Section 4, Figure 4.1). Outfalls 001, 015, 017, and 019 were monitored for KPDES permit parameters. *Title 40, Code of Federal Regulations, Part 136* (40 CFR 136), lists the specific sample collection, preservation, and analytical methods acceptable for the types of pollutants analyzed. Preservation in the field is conducted per 40 CFR 136, and chain-of-custody procedures are followed after collection and during transport to the analytical laboratory. The samples are then accepted by the laboratory and analyzed per 40 CFR 136 procedures for the parameters required by the KPDES permit.

Surface runoff from the closed C-746-S Residential Landfill, the closed C-746-T Inert Landfill, and the operating C-746-U Landfill was monitored quarterly. Grab samples were monitored for chloride, sulfate, pH, sodium, uranium, iron, total organic carbon, total suspended solids, total dissolved solids, and specific conductivity. The samples taken include

landfill runoff, the receiving ditch upstream of the runoff discharge point, and the receiving ditch downstream of the runoff discharge point (Section 4, Figure 4.2). Sampling was performed to comply with KDWM requirements for operation of the contained landfill.

Liquid Effluent Monitoring Results

Analytical results are reported to KDOW in monthly and quarterly DMRs. Four exceedences of permit limits were reported in 2000 for DOE Outfalls 001 and 017 (Table 7.1 and Section 2). Additional data are provided in Appendix C.

Outfall 001

Two noncompliances with KPDES parameters were reported in 2000 at Outfall 001. The noncompliances were for chronic toxicity of samples collected at the outfall. A TRE showed the toxicity to be from a fish pathogen. More detailed information is available in Section 2.

Outfall 017

Two noncompliances with KPDES parameters were reported in 2000 at Outfall 017. The noncompliances were for acute toxicity of samples collected at the outfall. A TRE indicated that the most likely source of the toxicity was from zinc washing off newly painted cylinders in DOE cylinder storage yards. The painting operation was ceased in 1998 and not resumed in 2000 because of the toxicity problems associated with painted cylinders. More detailed information is available in Section 2.

Table 7.1 KPDES permit exceedence summary for 2000

Outfall	Noncompliance Parameter	Date Sampled	Result	KPDES Limit
017	Acute Toxicity	January	1.36 TUa	1.0 TUa
017	Acute Toxicity	February	1.41 TUa	1.0 TUa
001	Chronic Toxicity	February	1.62 TUc	1.0 TUc
001	Chronic Toxicity	March	4.50 TUc	1.0 TUc

8 Nonradiological Environmental Surveillance

Abstract

The nonradiological environmental surveillance program at the Paducah Site assesses the effects of DOE operations on the site and the surrounding environment. Surveillance includes analyses of air, surface water, groundwater (Section 9), sediment, soil, vegetation, terrestrial wildlife, and fish and other aquatic life. Surveillance results for 2000 were similar to results reported in previous ASERs.

Introduction

Nonradiological environmental surveillance at the Paducah Site involves sampling and analysis of surface water, groundwater (see Section 9 for groundwater surveillance results), sediment, soil, terrestrial wildlife, and fish and other aquatic life. This section discusses the results of surveillance activities.

Ambient Air

As a result of the transfer of the production part of the plant to USEC in 1993, major air emission sources were transferred to USEC. Therefore, the Paducah Site is not required to conduct ambient air monitoring for nonradiological parameters.

Surface Water

Surface-water monitoring downstream of KPDES outfalls is not required by the KPDES permit. However, it is performed at the Paducah Site as part of the Environmental Surveillance Program. The net impact of the Paducah Site's activities on surface waters is evaluated by comparing data from samples collected at reference locations (Massac Creek and the Ohio River) and locations upstream and downstream of PGDP at Bayou and Little Bayou creeks. No sample point exists for upstream Little Bayou Creek as the watershed is insufficient to develop adequate flow to monitor. Most water in Little Bayou Creek is comprised of discharges from plant outfalls. Background water quality is derived from upstream Bayou Creek (L1). L29 and L64 are locations on reference waterways also used for comparisons with data for Bayou and Little Bayou creeks.

Quarterly surface-water samples are collected at the following locations: L1, L5, L10, L11, L29, L30, L56, L64, L194, L291, L306, and C746-K-5.

Semiannual samples are collected at L6. Table 8.1 shows the parameters analyzed, as well as corresponding results, at these locations.

Surface water samples are analyzed for various parameters and are not all located directly upstream or downstream of plant effluents. For example, L55 and L56 are located downstream of two plant outfalls and upstream of others so they represent only a portion of the effect of plant effluents. Similarly, L135, L136, L137, L150, L154, and L155 are sample locations only associated with landfill operations and do not represent upstream and downstream locations on Bayou and Little Bayou creeks (Figure 4.2). Therefore, these locations are not presented in Table 8.1 although data is provided in Appendix C.

Surface Water Surveillance Results

Table 8.1 shows a water chemistry comparison between upstream and downstream locations associated with the plant. Chloride, perhaps from winter salting of roads, was elevated downstream of PGDP in Bayou Creek. TCE was only detected at one location and that was upstream of plant effluents.

Phosphorous was elevated downstream in Little Bayou Creek. Phosphorous is used by USEC at PGDP in the plant recirculating water system. However, effluents from the recirculating water system are discharged via Bayou Creek, not Little Bayou Creek. Phosphorous is a component in fertilizer and the elevated numbers could be associated with farming operations along and near Little Bayou Creek.

Aluminum, iron, and copper were elevated at some Little Bayou Creek downstream locations but not at significant levels when compared to Ohio River levels. Cadmium was detected in one downstream Little Bayou Creek sample.

Uranium was detected at locations downstream of plant effluents. The uranium concentrations are well below DOE DCGs.

Surface water surveillance results can be compared to warm water aquatic habitat criteria established by KDOW (401 KAR 5:031).

Surface water samples are taken on a quarterly basis at the C-746-S&T closed landfills and the operating C-746-U landfill (Figure 4.2). Samples are taken upstream of surface runoff from the landfills, at the landfills, and downstream of the landfills. Contaminants associated with landfill leachate are monitored. Sample results do not indicate that the landfills are leaking to the surface. Data is reported quarterly to KDWM. Appendix C provides the results of surface water monitoring. Permit limits are not established or required. Samples are taken upstream of surface runoff from the landfills, at the landfills, and downstream of the landfills. Contaminants associated with landfill leachate are monitored. Sample results do not indicate that the landfills are leaking to the surface. Data are reported quarterly to KDWM. Appendix C provides the results of surface water monitoring. Permit limits are not established or required.

Sediment

Sediment is an important constituent of the aquatic environment. If a pollutant is a suspended solid or is attached to suspended sediment, it can either settle to the bottom (thus creating the need for sediment sampling), be taken up by certain organisms, or become attached to plant surfaces. Pollutants in solution can either adsorb on suspended organic and inorganic solids or be assimilated by plants and animals. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. Sediments play a significant role in aquatic ecology by serving as a repository for radioactive or chemical substances that pass via bottom-feeding biota to the higher trophic levels.

Table 8.1 Selected routine nonradiological surface water surveillance results (average concentrations)

Parameter	Units	L1 Upstream Bayou	L5 Down-stream Bayou	L6 Down-stream Bayou	L10 Down-stream Little Bayou	L11 Down-stream Little Bayou	L29 Up-stream Ohio River	L30 Down-stream Ohio River	L64 Massac Creek	L291 Up-stream Bayou	L306 Down-stream Ohio River at Cairo
2-Propanol	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aluminum	mg/L	0.4	0.2	0.04	0.4	1.5	1.1	1.2	0.02	0.3	0.7
Cadmium	µg/L	ND	ND	ND	ND	0.013	ND	ND	ND	ND	ND
Carbonaceous Brochemical Oxygen Demand	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	µg/L	13.6	56.2	32.8	31.3	21.35	19.0	19.0	12.1	11.6	21.1
Chromium	µg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Conductivity	µmho/cm	222.8	548.5	378.0	359.6	280.2	287.0	301.5	144.2	233.7	329.4
Copper	mg/L	ND	ND	0.017	ND	0.02	0.024	0.029	0.020	ND	ND
Dissolved Oxygen	mg/L	7.8	9.7	8.5	8.0	8.1	10.4	9.2	7.3	6.2	9.8
Flow	mgd	0.53	10.7	5.51	0.69	1.56	NM	NM	3.54	0.70	NM
Hardness	mg/L	61.4	133	94.0	90.2	76.2	123	126	54.0	74.0	151
Iron	mg/L	0.5	0.4	0.4	0.5	1.4	1.05	1.7	0.714	0.4	0.7
Lead	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PCB	µg/L	ND	ND	ND	ND	ND	7.82	ND	ND	ND	ND
PH[a]	std. units	7.2/7.7	7.2/8.9	7.2/7.5	7.2/7.7	7.2/8.0	7.4/8.3	7.7/8.1	6.9/7.4	7.2/7.7	7.5/8.1
Phosphorous	mg/L	0.11	0.11	0.01	0.22	0.26	0.08	0.09	0.065	0.09	0.08
Suspended Solids	mg/L	ND	ND	ND	ND	ND	31	35.5	ND	ND	67
Temperature	degrees F	60.6	65.4	70.4	60.3	60.2	60.2	63.7	64.7	65.3	63.3
TCE	µg/L	0.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
Uranium	mg/L	ND	0.009	0.008	0.010	0.009	ND	0.001	ND	ND	ND
Zinc	Mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[a] = pH minimum/maximum is given ND = not detected NM = not measured

Sediment Surveillance Program

Ditch sediments are sampled semiannually as part of a nonradiological environmental surveillance program. Sediment samples were taken from eleven locations in 2000 (Figure 5.2). Sediments were sampled for metals and PCBs.

Sediment Surveillance Results

Table 8.2 shows average concentrations for parameters where detects occurred. Aluminum, arsenic, barium, calcium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, and vanadium had the highest concentrations at upstream locations. This is not unusual because the concentrations are within the range of typical background levels (DOE 1996b). Little Bayou Creek had equivalent detectable quantities of beryllium both upstream and downstream of plant discharges. Zinc was found at background levels downstream of plant discharges. Chromium was found to be elevated in Little Bayou Creek when compared to upstream in Little Bayou Creek; 72 mg/kg and 15 mg/kg respectively. Past PGDP operations released chromium that was used as a corrosion inhibitor. Chromium is no longer used at PGDP.

Uranium was found at detectable levels downstream of plant discharges in both Bayou and Little Bayou creeks. This is expected due to the nature of uranium enrichment activities at PGDP. Discharges and releases of uranium have occurred over many years of operation.

PCBs were also found in Little Bayou Creek downstream of plant effluents at S2. Past spills of PCB oil, which is denser than water, have resulted in pockets of elevated PCB levels in creek sediments downstream of plant effluents. Finding PCBs appears to be a hit-or-miss proposition in creek sediments. For example, in 1999, no PCBs were detected in any sediments; however previous year sampling events indicated average concentrations as high as 2000 µg/kg at the S2 location (200 µg/kg in 2000).

Additional sediment data can be found in Appendix C.

Soil

The major source of soil contamination is from air pathways. Because DOE no longer controls any major air emissions sources, routine soil surveillance is not performed. However, surface-soil contamination is being addressed by the Surface Soils Operable Unit (see Environmental Restoration Program discussion in Section 3).

Vegetation

Because DOE no longer operates any major air emissions sources, routine vegetation surveillance activities are not performed.

Fish and Other Aquatic Life

Watershed (biological) monitoring was conducted under DOE Order 5400.1 and KPDES Permit KY0004049. The KPDES permit also requires toxicity monitoring of one continuous outfall and of three intermediate outfalls on a quarterly basis. Watershed or biological monitoring of Bayou and Little Bayou creeks has been conducted since 1987.

The objectives of the Watershed Monitoring Program are as follows:

- determine whether discharges from the Paducah Site and its associated SWMUs associated with the Paducah Site are adversely affecting instream fauna;
- assess the ecological health of Bayou and Little Bayou creeks;
- assess the degree to which abatement actions ecologically benefit Bayou and Little Bayou creeks;

Table 8.2 Selected routine nonradiological sediment surveillance results (average mg/kg)

Parameter	S1 Downstream Bayou	S2 Downstream Little Bayou	S20 Upstream Bayou	S21 Upstream Little Bayou	S27 Downstream Little Bayou	S28 Massac Creek	S33 Downstream Bayou	S34 Downstream Little Bayou
Aluminum	4540	3300	1190	5690	1900	1800	1750	2990
Arsenic	ND	ND	5.4	ND	3.5	ND	ND	ND
Barium	18	23	43	46.8	21.5	17	15	17.7
Beryllium	ND	ND	ND	0.36	0.36	ND	ND	ND
Calcium	563	430	490	907	275	172	201	292
Chromium	17.6	13.4	12.3	15.0	72.4	4.95	9.37	47.6
Cobalt	ND	2	4.0	4.5	2.3	1.9	2	2.9
Copper	5.98	5.7	3.46	6.0	5.4	5.49	3.0	4.8
Iron	6980	5500	6530	11800	7180	3900	5240	8770
Magnesium	319	269	118	551	187	178	164	172
Manganese	114	91	410	206	135	111	77	78
Nickel	4.39	3.82	ND	7.12	3.4	ND	ND	ND
PCB total	ND	200	ND	ND	ND	ND	ND	ND
Potassium	205	174	ND	208	ND	ND	ND	165
Uranium	ND	3.4	ND	ND	8.7	ND	2.8	3.7
Vanadium	15.2	13.8	15.9	24.1	15.0	8.2	9.2	19.6
Zinc	23	16.6	ND	ND	22	ND	15	ND

ND = Not Detected

- provide guidance for remediation;
- provide an evaluation of changes in potential human health concerns; and
- provide data that could be used to assess the impact of inadvertent spills or fish kills.

The 2000 sampling effort was conducted in accordance with the *Bayou Creek and Little Bayou Creek Watershed Monitoring Program* (ORNL 1998), otherwise known as the PGDP Watershed Monitoring Program Plan. The report was approved by KDOW as required by the KPDES permit.

Study Area and Methods

As specified by the PGDP Watershed Monitoring Program Plan, the fish and benthic macroinvertebrate communities were sampled only during one time period in September at the following locations: Bayou Creek (BBK 12.5, BBK 10.0, and BBK 9.1), Little Bayou Creek

(LUK 7.2), and Massac Creek (MAK 13.8). Sampling locations are shown in Figure 8.1. The bioaccumulation of PCBs in fish were monitored by collecting longear sunfish at three locations in Little Bayou Creek (LUK 9.0, LUK 7.2, and LUK 4.3) and by collecting spotted bass from one location in Bayou Creek (BBK 10.0). Massac Creek serves as the source of background fish (MAK 13.8) and is not shown in Figure 8.2.

Benthic macroninvertebrate samples were collected with a square-foot bottom sampler from randomly selected locations within each of the five sites. Samples were processed in a laboratory following standard operating procedures (SOPs). Organisms were identified to the lowest practical classification. Instream habitats located on the bank of the watercourse, and water quality, were assessed at each site following standard procedures outlined by EPA. An analysis of the data includes general descriptive information to evaluate trends in sequential and spastic changes that could be associated with decreasing activities or remedial actions. Metrics of the benthic macroinvertebrate community, such as total density, total taxonomic richness, taxonomic richness of the pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT), percent community similarity index, and dominants in common, are included in the analysis of the data.

Quantitative samplings of the fish communities at the five sites in the Paducah Site area were conducted by electrofishing. Areas ranging from eight to 120 meters at individual sampling sites were sampled by electrofishing methods using a three-pass removal estimate. Block nets were placed surrounding each area prior to commencement of sampling. Data from these samples were used to estimate species richness, population size (numbers and biomass per unit area), and annual production. Data were adapted to create an Index of Biotic Integrity that is consistent with KDOW 1986 guidelines. All fish sampling sites overlap sites used in the benthic macroinvertebrate community task. All field sampling was conducted according to SOPs.

The concentration of PCBs in fish was determined in longear sunfish (*Lepomis megalotis*) from the Little Bayou Creek sites and spotted bass *(Micropterus punctulatus*) from Bayou Creek. Filets of individual sunfish and composited filet samples of the spotted bass were analyzed for PCBs. These analyses were conducted using EPA-approved methods. In addition to blanks and laboratory control standards, standard reference materials, and/or spike samples of fish known to be uncontaminated, were run to demonstrate recovery of the analytes. Fish from background reference sites were also analyzed with each submission to demonstrate the absence of false positives or interferences, and establish background levels.

Watershed Monitoring

A detailed Watershed Monitoring Report is generated on an annual basis in accordance with the approved Watershed Monitoring Program Plan. Sampling for the 2000 report was completed during the month of September. The 2000 report concluded that historical contamination from PGDP is evident as fish in Bayou and Little Bayou creeks continue to have elevated PCB levels in tissue (CDM 2001). These levels, however, are on the decline based on PCB levels in fish tissue data that have been collected from 1990 to 2000 (ORNL 1994a, ORNL 1994b, ORNL 1996a, ORNL 1996b, ORNL 1997, ORNL 1998, ORNL 1999, CDM 2000, and CDM 2001). A concern is the relative high concentrations found in fish collected during the 1998 sampling effort. Levels observed for 1999 sampling were reduced, but other parameters of the fish communities examined were different than in previous years. For the 2000 report, a slight increase occurred from the 1999 levels, but still a decrease from the 1998 concentration. This year's slight increase may be a reflection of sampling older/larger fish where bioaccumulation of PCBs had occurred.

Macroinvertebrate fauna were significantly different in the downstream sampling sites as compared to the upstream (BBK 12.5) and reference (MAK 13.8) sites. Although these differences could not be directly attributed to contaminant discharge from the PGDP, future

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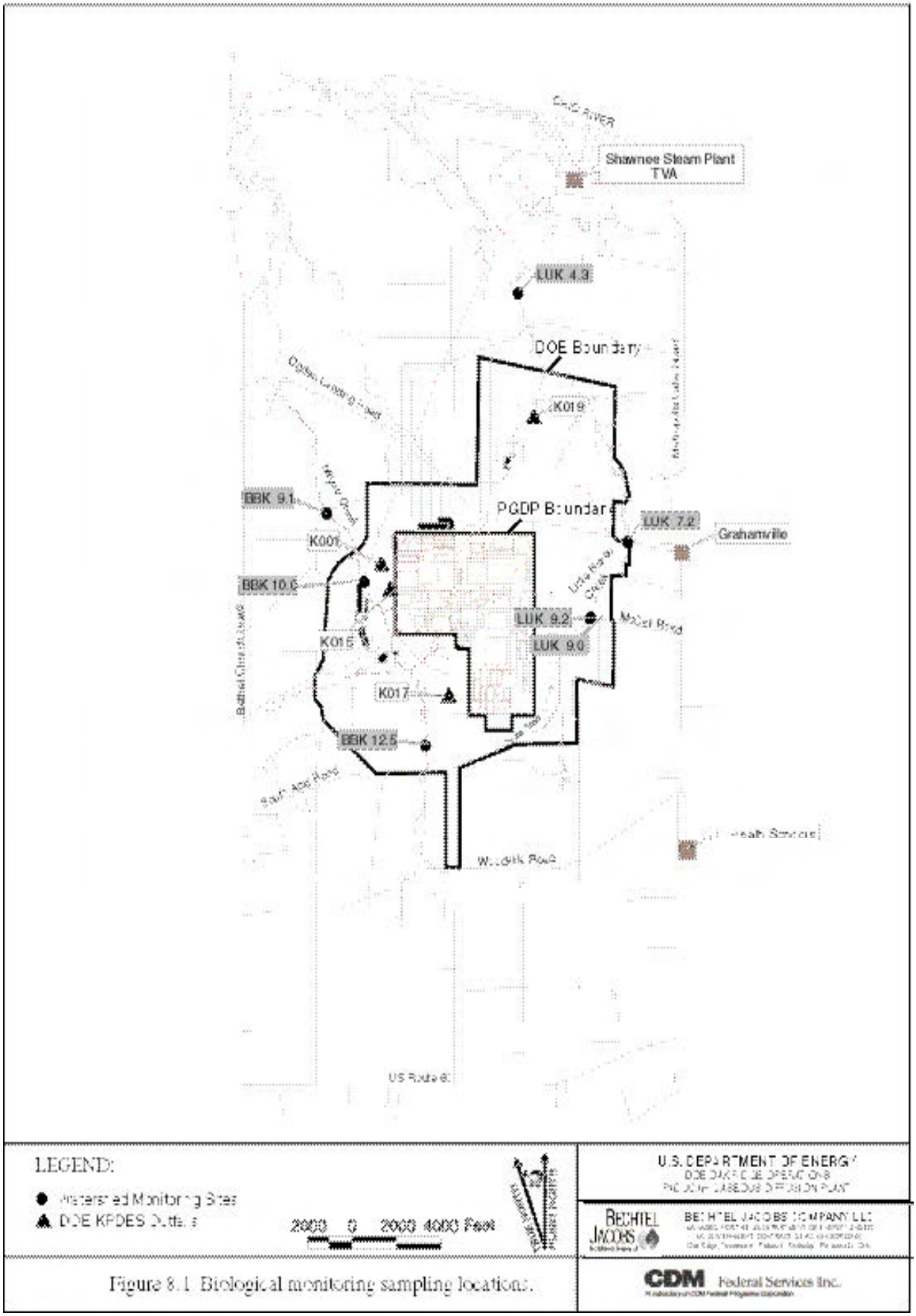

Figure 8.1 Biological monitoring sampling locations.

Table 8.3 Average concentration of PCBs (µg/g wet weight) in filets of fish from streams near the Paducah Site, September 2000

Site[a]	Species[b]	Mean[c]	Range	n
BBK 10.0	Spotted bass	0.14	0.14	1
LUK 9.0	Longear sunfish	0.64	0.5-1.02	6
LUK 7.2	Longear sunfish	0.40	0.22-0.82	6
LUK 4.3	Longear sunfish	0.08	0.06-0.11	4
MAK 13.8	Longear sunfish	<0.05	N/A	6
MAK 13.8	Spotted bass	<0.05	N/A	1

[a] BBK = Bayou Creek kilometer; LUK = Little Bayou Creek kilometer; MAK = Massac Creek kilometer

[b] Spotted bass = *Micropterus punctulatus;* Longear sunfish = *Lepomis megalotis;*

[c] Value of half the detection limit was used in calculating means for non-detect samples

n Number of samples

sampling will be evaluated to include a downstream macroinvertebrate sample on Massac Creek. Such a site may clarify whether changes in the macroinvertebrate fauna are due to PGDP discharge or the fact that the sites are associated with the Ohio River floodplain and therefore, are ecologically different.

The ecological health of Bayou and Little Bayou creeks is of concern based upon the findings of the macroinvertebrate, fish faunas, and biomass studies. Significant changes have occurred within the macroinvertebrate population with declines in the fish density and biomass at the BBK and LUK sites. However, a similar decline has occurred on the Massac Creek site, suggesting that a complex ecological event may be occurring that is affecting the ecology of the whole drainage area. All sampling sites show continued species diversity. The population density reductions remain a concern. Biomass reductions at all of the sites sampled suggest that ecological events probably account for the observed declines. These creeks will continue to be monitored closely.

Bioaccumulation of PCBs in fish tissue has declined in recent years, suggesting decreased PCB levels from the Paducah Site KPDES outfalls. Levels of bioaccumulation of PCBs recorded during 2000 are still of biological significance.

Therefore, concern still exists for the possible release of PCBs and other toxicants (metals and radionuclides) during major rainfall. Continued implementation of erosion control measures around the site will reduce the likelihood of the additional release of PCBs during major rainfall. A summary of the mean concentration of PCBs in fish filets sampled in Bayou and Little Bayou creeks as well as the reference locations in Massac Creek are provided in Table 8.3. It should be noted that all fish sampled exhibited PCB concentrations well below the U.S. Food and Drug Administration Action Level of 2.0 parts per million (ppm) as referenced in 29 CFR 109.30.

Toxicity Monitoring

The toxicity of effluents from the continuously flowing Outfall 001 and intermittently flowing Outfalls 015, 017, and 019 were monitored using water fleas (*Ceriodaphnia dubia*) and fathead minnow (*Pimephales promelas*) larvae. Toxicity tests were conducted as required by the KPDES permit and TRE plans. Short-term 48-hour toxicity tests (also known as acute tests) were conducted for Outfalls 015, 017, and 019, and longer term six- or seven-day toxicity tests (also known as chronic tests) were conducted for Outfall 001. For the acute toxicity test data, the 48-hour LC_{50} (concentration that is lethal to 50% of the test organisms) was determined and the TU_a was

calculated ($TU_a = 100/LC_{50}$). For the chronic toxicity test data, the 25% inhibition concentration (IC_{25}, that concentration causing a 25% reduction in fathead minnow growth, *Ceriodaphnia* reproduction compared to a control) was determined and the TU_c was calculated ($TU_c = 100/IC_{25}$). The TU_a and TU_c are compliance endpoints in the KPDES permit. For permitting purposes, KDOW has determined that Little Bayou and Bayou creeks have a low-flow zero; thus a toxicity unit (TU) > 1.0 would be considered a noncompliance and an indicator of potential instream toxicity. A TU $\geq$ 1.2 is considered a significant noncompliance.

During 2000, four toxicity exceedences were noted at KPDES Outfalls 001 and 017. Details are provided in sections 2 and 7.

Terrestrial Wildlife

Annual Deer Harvest

The deer population in WKWMA is sampled annually to determine levels of radionuclides (Section 5), PCBs, and inorganic elements that might be attributed to past plant practices. There were eight deer harvested from WKWMA and two deer harvested from the BWMA to serve as reference samples.

PCBs tend to accumulate in fat tissue. PCBs were found in the fat tissue of seven of the ten deer harvested in 2000. Five of the eight deer harvested at WKWMA had measurable PCB-1260 present and both of the reference BWMA deer had measurable PCB-1260 present. No other forms of PCBs were detectable. In 1999, no PCBs were found in any of the tissues of deer harvested. The laboratory detection limits utilized in 2000 were lower than in prior years, which may have lead to the identification during the 2000 sampling. A risk assessment was conducted using the concentrations of PCB found in deer, assuming 20% fat content and that a hunter would eat the two deer with the highest quantities of PCBs found. The risk assessment concluded that the risk to the hunter who eats 100 pounds of the two worst-case deer would have an average increased cancer risk of 0.000004, or approximately four chances of cancer development per one million people who eat the deer.

There were no unusual findings in metal analysis of deer. Silver was found in one reservation deer liver sample and one BWMA deer muscle sample. Aluminum was found in the kidneys of both BWMA deer. Metals were not elevated in the WKWMA deer when compared to the BWMA deer. Additional data can be found in Appendix C.

9 Groundwater

Abstract

The primary objectives of groundwater monitoring at the Paducah Site are to detect contamination and provide the basis for groundwater quality assessments if contamination is detected. Monitoring includes the exit pathways at the perimeter of the plant and off-site water wells. Primary off-site contaminants continue to be TCE, which is an industrial degreasing solvent, and ^{99}Tc, which is a fission by-product. Evidence suggests the presence of dense nonaqueous phase liquids (DNAPL) on-site.

Introduction

Monitoring and protection of groundwater resources at the Paducah Site are required by federal and state regulations and by DOE orders. Federal groundwater regulations generally are enacted and enforced by EPA. The Paducah Site lies within EPA Region IV jurisdiction. EPA Region IV encompasses the southeastern United States and maintains headquarters in Atlanta, Georgia. Many state groundwater regulations are enacted and enforced by KDWM located in Frankfort, Kentucky. A KDWM field office for western Kentucky is located in Paducah.

When off-site contamination from the Paducah Site was discovered in 1988, the EPA and DOE entered into an ACO. DOE provided an alternate water supply to affected residences. Under CERCLA, DOE is also required to determine the nature and extent of off-site contamination through sampling of potentially affected wells and a comprehensive site investigation.

A CERCLA/ACO site investigation, completed in 1991, determined off-site contaminants in the RGA to be TCE, used as an industrial degreasing solvent, and ^{99}Tc, a fission byproduct contained in nuclear power reactor returns that were brought on-site several years ago for reenrichment. Such reactor returns are no longer enriched. Known or suspected sources of TCE and ^{99}Tc include burial grounds, former test areas and other facilities, spills, leaks, and leachate derived from contaminated scrap metal.

Investigations of the on-site source areas of TCE at the Paducah Site are ongoing. A common degreasing agent, TCE is considered a DNAPL with typically low solubility in water. DNAPLs either sink to the bottom of aquifers or come to rest on a less-permeable layer within an aquifer, forming pools. These DNAPL pools form a continuous source for dissolved-phase contamination (plumes) that are migrating off-site toward the Ohio River (Figure 9.1). Pools of DNAPL are extremely difficult to clean up. Currently, only the highest concentrations of dissolved TCE are controlled by pump-and-treat

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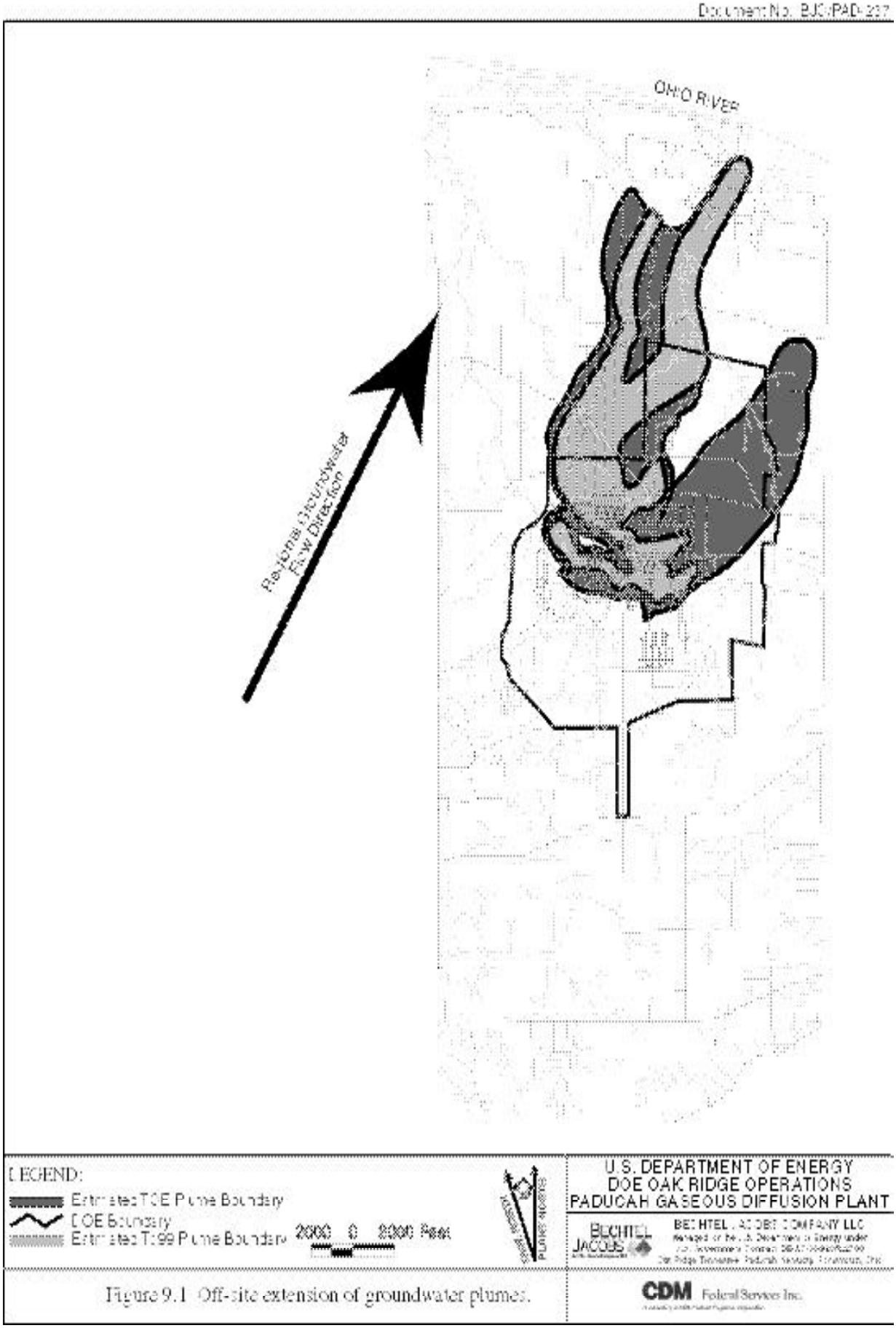

Figure 9.1 Off-site extension of groundwater plumes.

systems at Paducah. The pump-and-treat system installed northwest of the plant also controls the highest concentrations of dissolved ^{99}Tc that would otherwise migrate off-site. Continued groundwater monitoring serves to identify the extent of contamination, predict the possible fate of the contaminants, and determine the movement of groundwater near the plant. To date, four groundwater plumes have been identified emanating from the Paducah Site (Figure 9.1). Appendix D provides additional information about these plumes.

Groundwater monitoring at Paducah complies with one or more federal or state regulations and permit conditions and includes perimeter exit pathway monitoring and off-site water well monitoring. (See Groundwater Monitoring Program.) Figures 9.2 and 9.3 show the locations of all wells sampled during 2000. Analytical results from the sampling described in this section are available on request from the BJC Public Affairs Group.

Groundwater Hydrology

A portion of rainwater accumulates as groundwater by soaking into the ground, infiltrating porous soil and rock. The accumulation of groundwater in pore spaces of sediments creates an aquifier, which is a source of useable water (Figure 9.4). Water from the surface moving down through the soil makes its way by percolating downward through the pore spaces between soil grains (Figure 9.5). The smaller the pore spaces, the slower the flow of water through the sediment. The physical property that describes the ease with which water can move through the pore spaces and fractures in a material is called hydraulic conductivity, or permeability. Aquifers are found in permeable sediments such as sand and gravel and less permeable sediments, such as clay, shale and dense limestone make up aquitards that restrict groundwater movement. The boundary between the unsaturated and saturated zones is known as the water table. This boundary usually, but not always, gently mirrors the surface topography, rising above natural exits such as springs, swamps, and beds of streams and rivers; however, groundwater is discharged to the surface.

Groundwater movement is determined by differences in hydraulic head (a function of the energy associated with the water's elevation above sea level and the pressures exerted on it by surrounding water). Water will rise in a well casing in response to the pressure of the water surrounding the well's screened zone. The depth to water in the well is measured and the elevation calculated to determine the hydraulic head of the water in the monitored zone (Figure 9.6). The hydraulic gradient measures the difference in hydraulic head over a specified distance. By comparing the water levels in adjacent wells screened in the same zone, a horizontal hydraulic gradient can be determined and the lateral direction of groundwater flow can be predicted. Only wells screened in the same zones are considered when determining the horizontal gradient. Wells screened above and below an aquitard can also have different hydraulic heads, thus defining a vertical gradient. If the water levels in deeper wells are lower than those in shallower wells, the vertical component of flow is downward.

Permeability of the subsurface strata containing the aquifer also plays an essential role in the direction of groundwater flow through an aquifer system. Because the earth's sediments and their permeability vary greatly, groundwater flowing through subsurface strata does not travel at a constant rate or without impediment. As groundwater moves in the downgradient direction, it has both a horizontal and vertical component, just as a household drain moves tap water both horizontally and vertically, seeking the lowest point of exit. Aquitards deflect groundwater movement as drainpipe walls control the direction of tap water movement. In an aquifer constrained by aquitards such as horizontal clay layers, the downgradient direction tends to be more horizontal than vertical.

Groundwater aquifers are one of the primary pathways by which potentially hazardous substances can spread through the environment. Substances placed in the soil may migrate

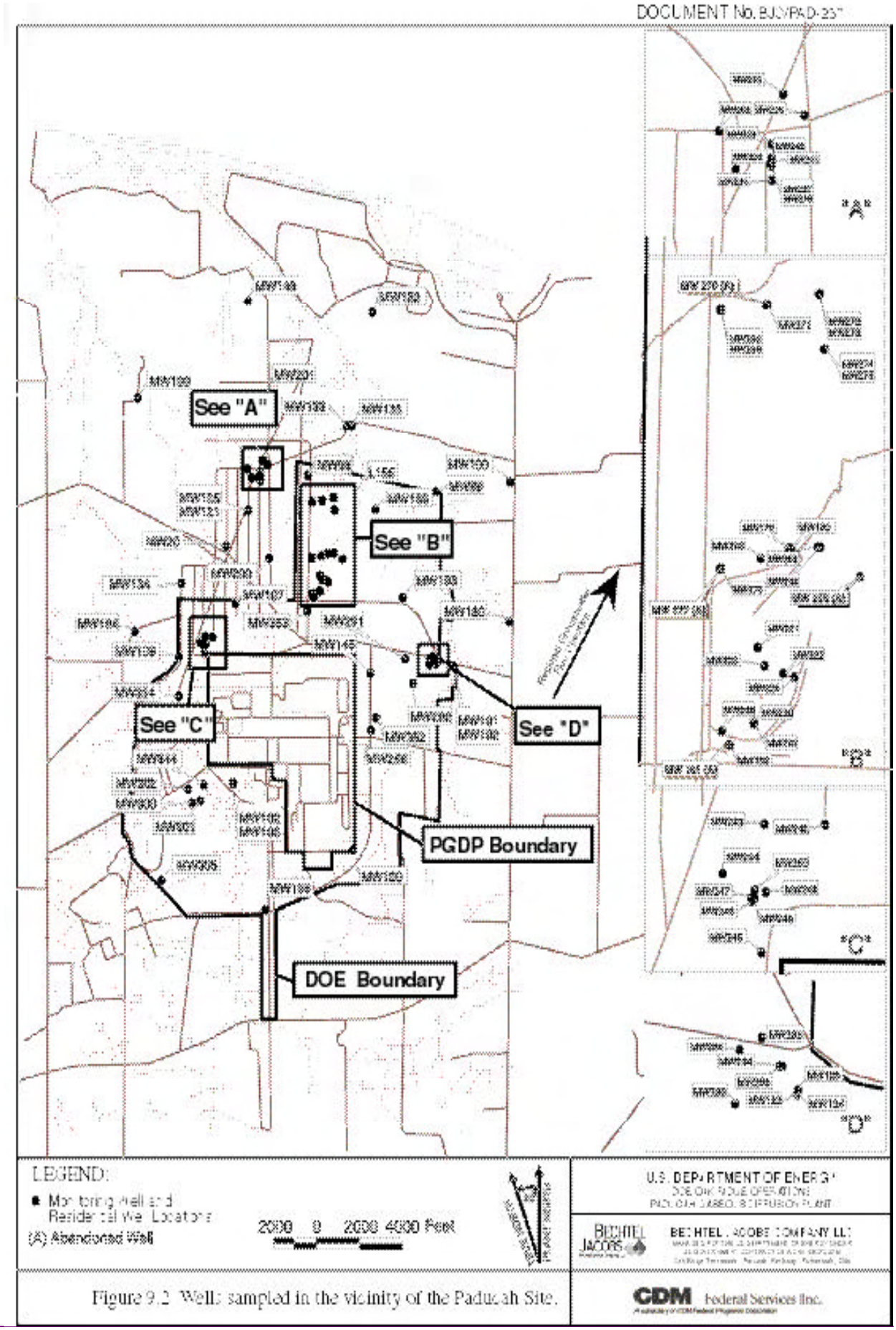

Figure 9.2 Wells sampled in the vicinity of the Paducah Site.

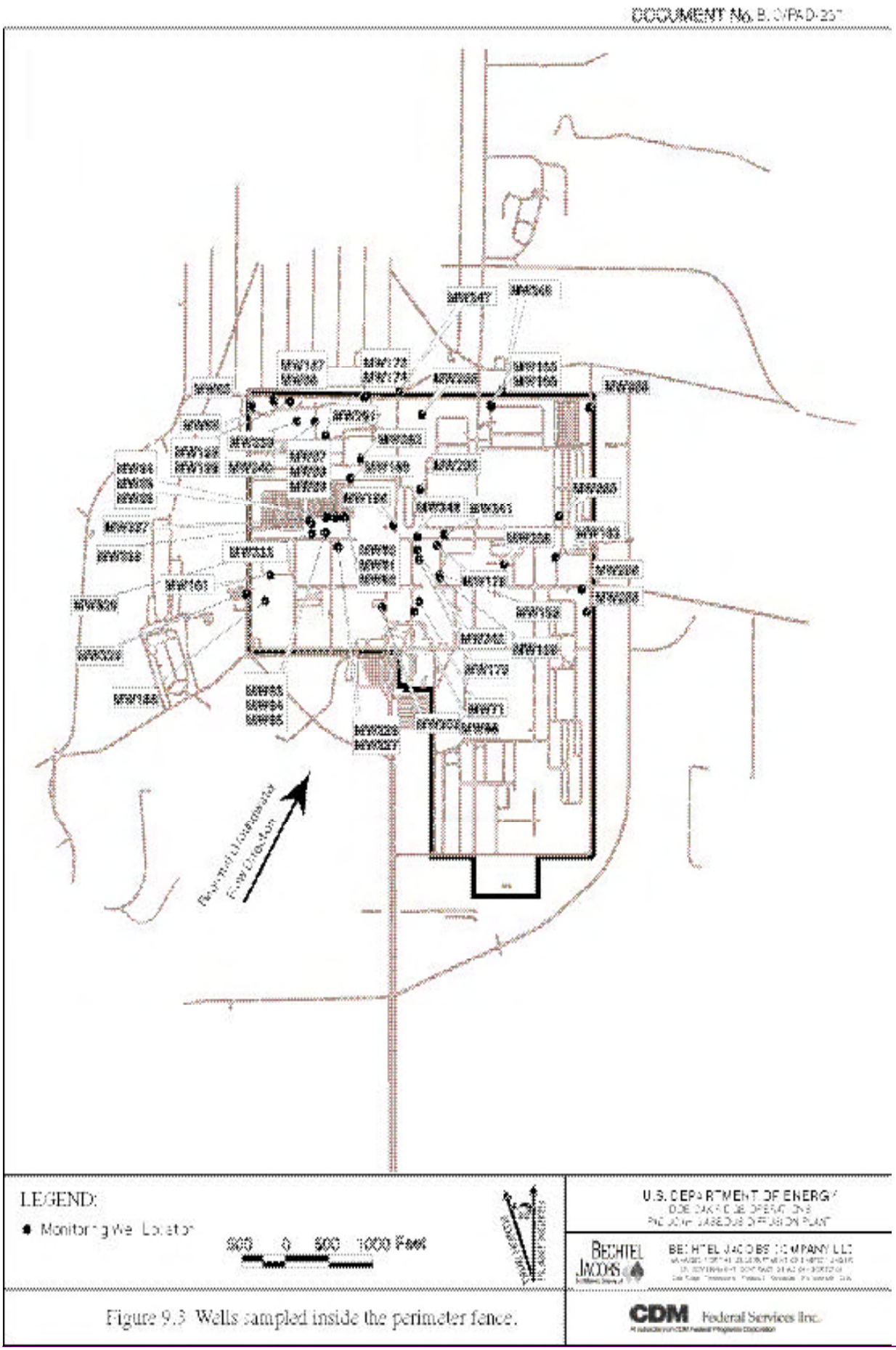

Figure 9.3 Wells sampled inside the perimeter fence.

downward due to gravity or be dissolved in rainwater, which moves them downward through the unsaturated zone into the aquifer. The contaminated water then flows downgradient toward the discharge point. MWs are used extensively to assess the effect of plant operations on nearby groundwater quality. Wells positioned to sample groundwater flowing away from a site are called downgradient wells, and wells placed to sample groundwater before it flows under a site are called upgradient wells. Any contamination of the downgradient wells not present in the upgradient wells at a site may be assumed to be a product of that site. Wells can be drilled to various depths in the saturated zone and be screened to monitor the recharge area above the aquifer, different horizons within the aquifer, or water-bearing zones below the aquifer. Vertical and horizontal groundwater flow directions are determined by the permeability and continuity of geologic strata, in addition to hydraulic head. To effectively monitor the movement of groundwater and any hazardous constituents it may contain, hydrogeologists at the Paducah Site have undertaken many detailed studies of the geology of strata beneath the site.

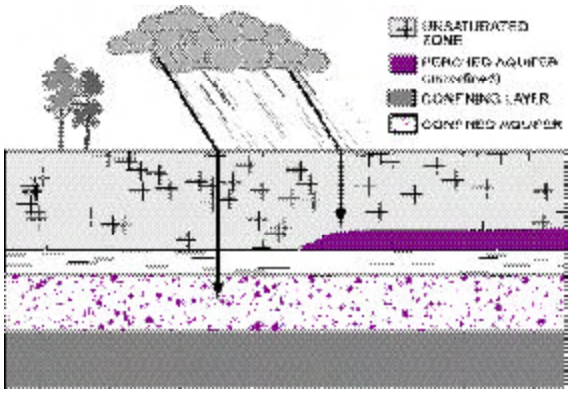

Figure 9.4 Typical path for rainwater accumulation as groundwater.

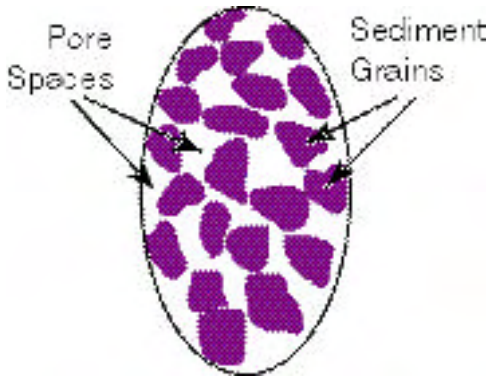

Figure 9.5 Pore spaces in soil.

Geologic and Hydrogeologic Setting

The Paducah Site, located in the Jackson Purchase region of western Kentucky, lies within the northern tip of the Mississippi Embayment portion of the Gulf Coastal Plain Province. The Mississippi Embayment is a large sedimentary trough oriented nearly north-south that received sediments during the Cretaceous and Tertiary geologic time periods. Figure 9.7 is a schematic cross-section illustrating regional stratigraphic relationships in the vicinity of the Paducah Site.

During the Cretaceous Period, sediments deposited in a coastal marine environment, creating the McNairy Formation. For the most part, the McNairy Formation is sandy at the bottom and silty at the top. There are areas of the McNairy Formation that vary such as lenses of clay and at least one fairly continuous string of gravel.

The Clayton Formation is above the McNairy. The Clayton Formation was deposited during the early Paleocene geologic epoch in an environment so

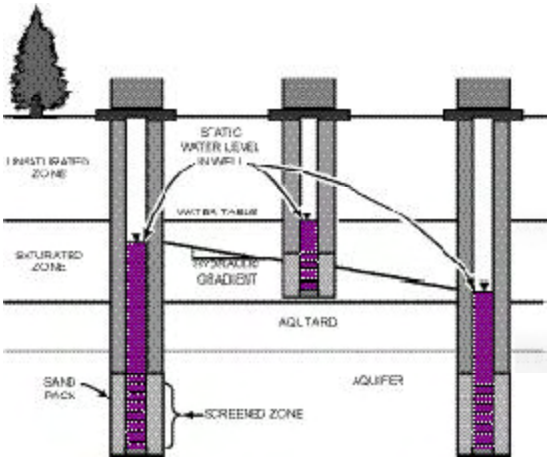

Figure 9.6 Monitoring well construction showing relationship between screened zone and water level in wells where limited flow in the aquifer is to the right.

similar to that of the McNairy that the Clayton and upper portion of the McNairy are indistinguishable in lithologic samples. Later in the Paleocene, the Porters Creek Clay was deposited in marine and brackish water environments in a sea that occupied most of the Mississippi Embayment. The McNairy/Clayton and the Porters Creek Clay formations, dip 9 to 10.5 m (30 to 35 ft) per mile to the south-southwest.

The next feature in the geologic history at the Paducah Site is a Pleistocene-age river valley occupying approximately the same position as the present-day Ohio and Tennessee river valleys. In forming the valley, braided stream channels of the ancestral Tennessee River, and possibly several "feeder" streams, eroded any sediments deposited after the Paleocene Porters Creek Clay and before the Pleistocene. The river system also eroded portions of the Porters Creek Clay and the McNairy formation and cut a prominent terrace in the Porters Creek Clay at the south end of the plant. The sediments deposited on this erosional surface are termed continental deposits. The lower portion of the continental deposits consists of approximately 9 m (30 ft) of stream gravel and sand.

Over time, sediments from the retreating glaciers dammed the river valley, causing the formation of a lake. Silts and clays with thin zones of sand and occasional gravel were deposited in the lake, forming the upper portion of the continental deposits. These deposits range from approximately 1.5 to 17 m (5 to 55 ft) thick.

Finally, loess, a wind-blown silt, overlies the continental deposits throughout the site. Thickness of loess deposits varies from approximately 1.5 to 8 m (5 to 25 ft), averaging approximately 4.6 m (15 ft). The local groundwater flow system at the Paducah Site contains the following four major components: (1) the McNairy flow system, (2) RGA, (3) the UCRS, and (4) the terrace gravels.

- The McNairy flow system consists of interbedded and interlensing sand, silt, and clay of the McNairy Formation. Sand facies account for 40 to 50% of the total formation thickness of approximately 69 m (225 ft).
- The RGA consists of sand and gravel facies in the lower continental deposits, gravel and coarse sand portions in the upper McNairy that are directly adjacent to the lower continental deposits, coarse-grained sediments at the base of the upper continental deposits, and alluvium adjacent to the Ohio River. These deposits have an average thickness of 9 m (30 ft) and range

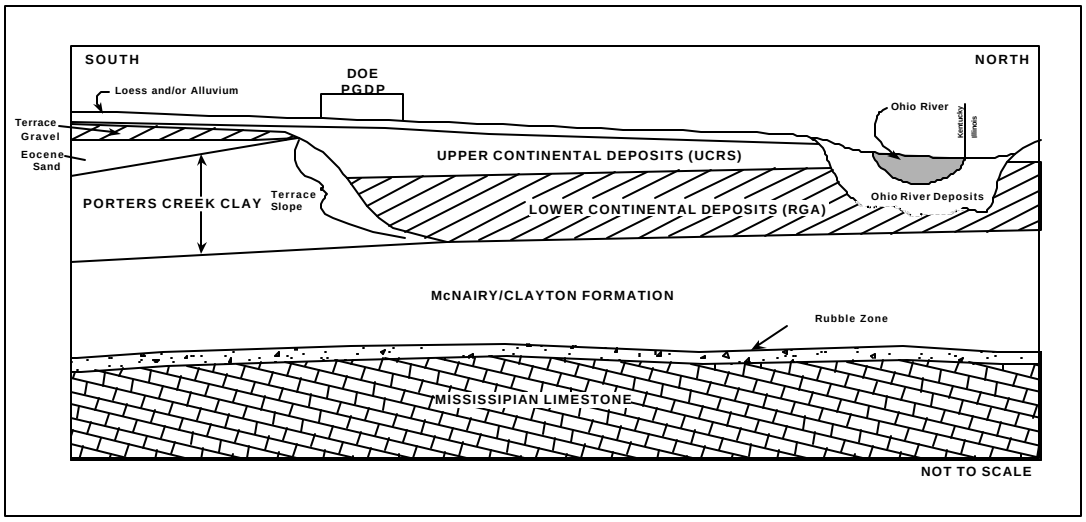

Figure 9.7 North-south section showing regional stratigraphic relationships.

up to 21 m (70 ft) along an axis that trends east-west through the site. The RGA is the uppermost and primary aquifer, formerly used by private residences north of the Paducah Site.

- The UCRS mainly consists of clayey silt with interbedded sand and gravel in the upper continental deposits. The system is so named because of its characteristic recharge to the RGA.
- The terrace gravels consist of shallow Pliocene gravel deposits in the southern portion of the plant site. These deposits usually lack sufficient thickness and saturation to constitute an aquifer but may be an important source of groundwater recharge to the RGA.

Groundwater flow originates south of the Paducah Site within Eocene sands and the terrace gravels. Groundwater within the terrace gravels either discharges to local streams or recharges the RGA, although the flow regime of the terrace gravels is not fully understood. Groundwater flow through the UCRS is ultimately downward, also recharging the RGA. From the plant site, groundwater flows generally northward in the RGA toward the Ohio River, which is the local base level for the system.

Uses of Groundwater in the Vicinity

The WKWMA and some lightly populated farmlands are in the immediate vicinity of the Paducah Site. Homes are sparsely located along rural roads in the vicinity of the site. The following three communities lie within 3.2 km (2 miles) of the plant: Magruder Village to the southwest and Grahamville and Heath to the east.

Both groundwater and surfacewater sources have been used for water supply to residents and industries in the plant area. Wells in the area are screened at depths ranging from 4.6 to 75 m (15 to 245 ft). The majority of these wells are believed to be screened in the RGA. The Paducah Site continues to provide municipal water to all residents within the area of groundwater contamination from the site. These residents' out-of-service wells are utilized by DOE for sampling as a result of written agreements. Residential wells that are no longer sampled have been capped and locked.

Groundwater Monitoring Program

The primary objectives of groundwater monitoring at the Paducah Site are early detection of any contamination resulting from past and present land disposal of wastes and provision of the basis for developing groundwater quality assessments if contamination is detected. Additional objectives outlined in DOE Order 5400.1, *General Environmental Protection Program*, require that groundwater monitoring at all DOE facilities "... determine and document the effects of operations on groundwater quality and quantity." The order specifically requires groundwater monitoring to be conducted on-site and in the vicinity of DOE facilities to accomplish the following:

- obtain data to determine baseline conditions of groundwater quality and quantity;
- demonstrate compliance with, and implementation of, all applicable regulations and DOE orders;
- provide data to permit early detection of groundwater pollution or contamination;
- provide a reporting mechanism for detected groundwater pollution or contamination;
- identify existing and potential groundwater contamination sources and maintain surveillance of these sources; and
- provide data for making decisions about land disposal practices and the management and protection of groundwater resources.

These objectives are outlined in the following three documents related to groundwater monitoring: *Paducah Gaseous Diffusion Plant Groundwater Protection Program Management Plan* (LMES 1997), *Groundwater Protection Plan* (BJC 1998), and the *Paducah Site Environmental Monitoring Plan* (BJC 2000b). Scheduled sampling continues for more than 150 MWs and residential wells in accordance with DOE orders and federal, state, and local requirements. Well sampling is included in several different monitoring programs, which are described below.

Resource Conservation Recovery Act Permit Monitoring Programs

Presently, the only hazardous waste facility at the Paducah Site that requires groundwater monitoring is the C-404 Landfill (Figure 9.8). The C-404 Low-Level Radioactive Waste Burial Ground was used for the disposal of uranium-contaminated solid wastes until 1986 when it was determined that, of the wastes disposed there, gold dissolver precipitate was considered a hazardous waste under RCRA. The landfill was covered with a RCRA-compliant clay cap and was certified closed as a hazardous waste landfill in 1987. The landfill is now monitored under post-closure monitoring requirements. According to the Kentucky C-404 Post Closure Permit, 14 wells (MWs 84–95, 226, and 227) monitor groundwater quality of the UCRS (four wells) and the underlying RGA (ten wells) during the required post-closure care on a semiannual basis.

During 2000, MWs at the C-404 Landfill were sampled and analyzed for total and dissolved arsenic, cadmium, chromium, lead, mercury, selenium, and TCE. Evaluation of the groundwater monitoring data collected at the C-404 Landfill includes immediate reporting to KDWM of results in RGA wells exceeding Kentucky MCLs (401 KAR 47:030, Section 6) and statistical analysis of the results for constituents that do not have an MCL.

During 2000, TCE exceeded contaminant levels in five upgradient RGA wells and two downgradient RGA well. Chromium also exceeded contaminant levels in two upgradient RGA well. KDWM was notified of the exceedences and results were reported to KDWM on a quarterly basis. A summary of the maximum results for each of the wells is provided in Table 9.1.

State Solid Waste Disposal Regulations

Post-closure groundwater monitoring continues for the C-746-S Residential Landfill. The landfill stopped receiving solid waste before July 1, 1995, and was certified closed on October 31, 1995, by an independent engineering firm. The groundwater monitoring system for the C-746-S Residential Landfill also encompasses the C-746-T Inert Landfill, which was certified closed in November 1992. The C-746-T Inert Landfill has fulfilled its two years of post-closure environmental monitoring and maintenance requirements and is awaiting final closure approval from KDWM.

The groundwater monitoring system for C-746-S and C-746-T consists of three upgradient and nine downgradient wells (Figure 9.9). The monitoring system is designed to monitor both the upper portion of the RGA (URGA) and lower portion of the RGA (LRGA). Upgradient wells are recognized as MW 181 (abandoned), MW 220, and MW 267, while downgradient wells are recognized as MW 179, MW 221 through MW 225, and MW 263 through MW 266. An additional well, MW 225, is monitored for static water level only. During 1999, MW 353 was installed as a new upgradient well because the proximity of MW 181, MW 220, and MW 267 to the landfill and apparent groundwater mounding within the aquifer created question of the true upgradient nature of the wells. MW 353 will be added to the monitoring system and the permit when eight quarters of sampling have been completed. At the request of KDWM, MWs are being abandoned and replaced due to questionable integrity. A revised groundwater monitoring plan has been submitted for review.

The MWs are sampled quarterly and in accordance with Kentucky Administrative Regulations (401 KAR 48:300). The analytes are

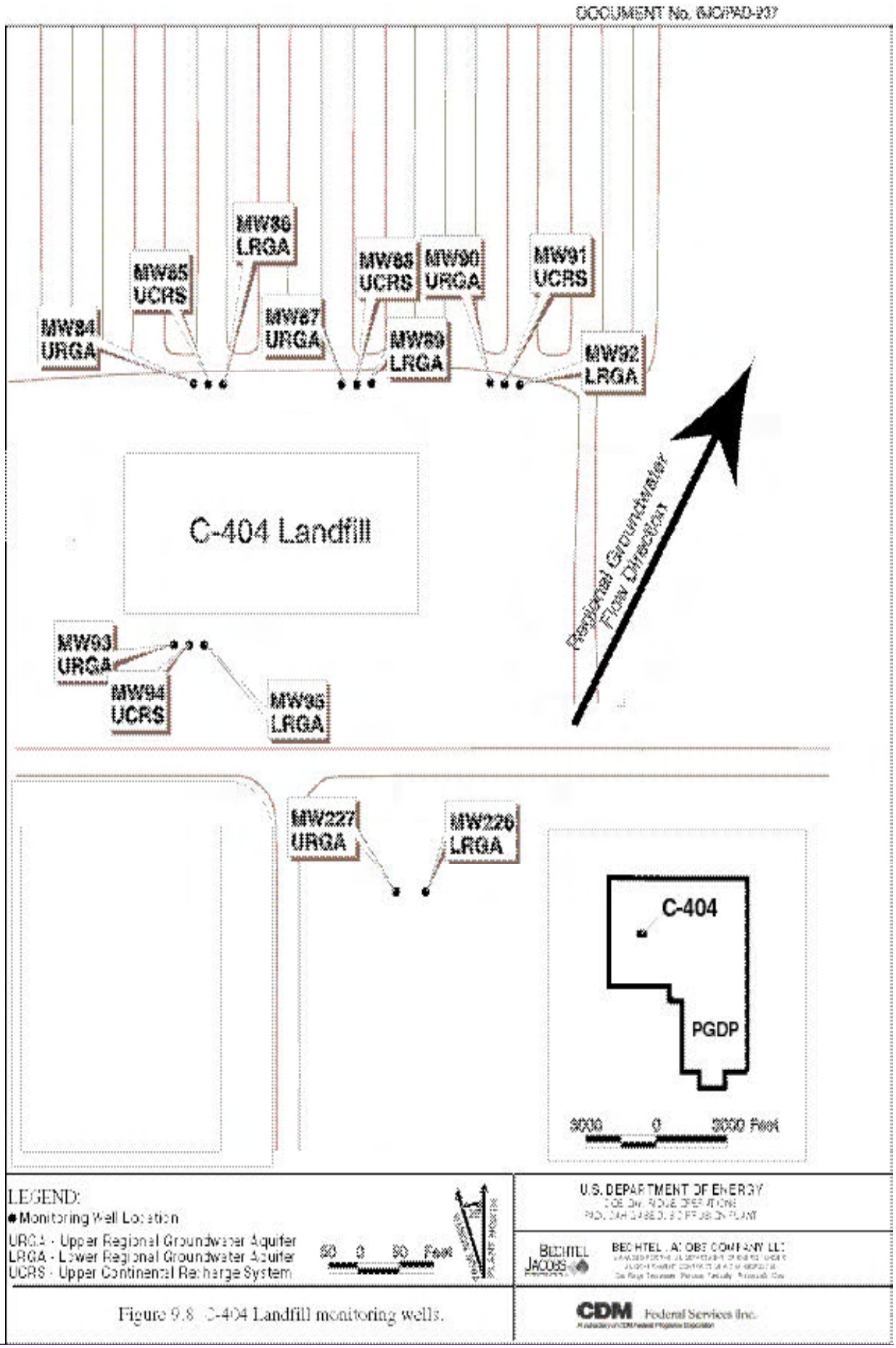

Figure 9.8. C-404 Landfill monitoring wells.

Table 9.1 Summary of maximum groundwater results from the RGA at C-404

	Upgradient Wells					Downgradient Wells					
Parameter	MW 226	MW 227	MW 93	MW 95	MW 84	MW 86	MW 87	MW 89	MW 90	MW 92	MCL
Arsenic (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Cadmium (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
Chromium (mg/L)	**0.113**	**0.055**	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Chromium, Dissolved (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Lead (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
Mercury (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.002
Selenium (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01
TCE (ug/L)	**71**	**6**	**24**	**13**	**17**	**8**	2	ND	3	ND	5
Technetium-99 (pCi/L)	148	ND	ND	20.2	ND	ND	ND	ND	18	ND	900

[**Bold**] = Exceeds Kentucky MCLs
ND = Non detects

dictated by a KDWM approved solid waste landfill permit modification. Evaluation of the groundwater monitoring data collected at the C-746-S and C-746-T landfills requires immediate reporting to KDWM of results exceeding Kentucky maximum contaminant levels (401 KAR 47:030 Section 6) and statistical analysis of the results for constituents that do not have a maximum contaminant level.

During 2000, TCE exceeded contaminant levels in five downgradient wells; chromium exceeded contaminant levels in three upgradient wells and six downgradient wells; and beta activity exceeded contaminant levels in two upgradient wells. KDWM was notified of the exceedences, as required by the permit. Results were reported to KDWM on a quarterly basis. A summary of the maximum results for each of the wells is provided in Table 9.2.

A solid waste landfill at the Paducah Site, identified as the C-746-U Contained Landfill, was completed in 1996 and operation initiated in 1997. Solid waste regulations require groundwater characterization of the uppermost aquifer down to and including the clusters (Figure 9.9). Each cluster is made up of one well in the URGA and one well in the LRGA. One well cluster (MW 276 and MW 277) is located upgradient of the facility and four wells downgradient. At the request of KDWM, MWs are being abandoned and replaced due to questionable integrity. A revised groundwater monitoring plan has been submitted for review.

Evaluation of the groundwater monitoring data collected at the C-746-U Landfill included, for permitted wells, immediate reporting to KDWM of results exceeding Kentucky MCLs (401 KAR 47:030, Section 6) and statistical analysis of the results for constituents that do not have a maximum contaminant level. During 2000, TCE exceeded contaminant levels in two upgradient wells; chromium exceeded contaminant levels in all wells; and beta activity exceeded contaminant

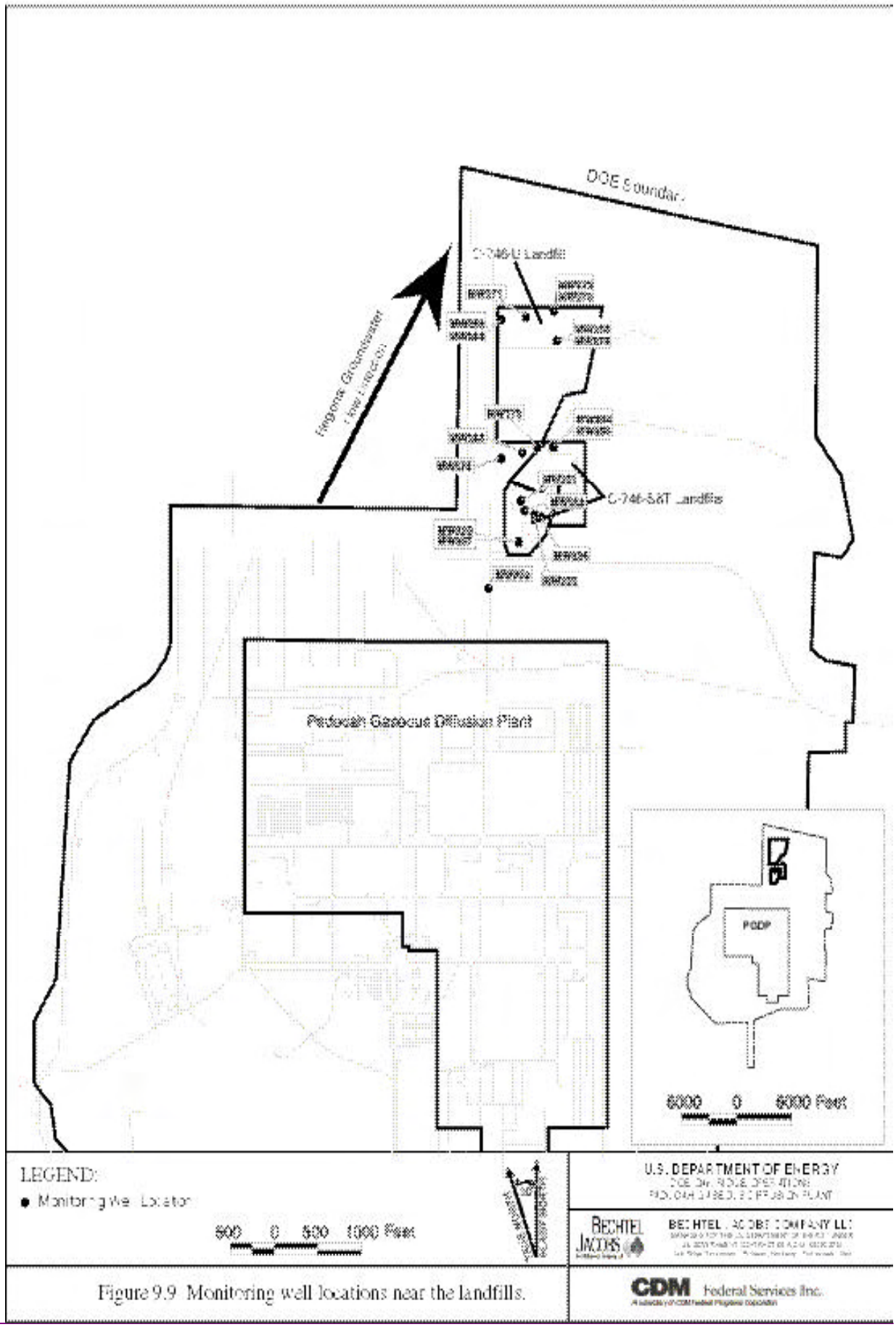

Figure 9.9 Monitoring well locations near the landfills.

Table 9.2 Summary of maximum groundwater results for C-746-S&T

	Analysis	Upgradient Wells (MW####)				Downgradient Wells (MW###)									
		181	220	267	353	179	221	222	223	224	263	264	265	266	MCL
Metal	Barium	0.252	0.224	0.246	0.117	0.029	0.253	0.334	0.229	0.242	0.067	0.166	0.238	0.05	1
	Barium, Dissolved	ND	0.224	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1
(mg/L)	Calcium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	24.4	ND	
	Chromium	**0.362**	**0.079**	**0.395**	ND	ND	**0.141**	**0.093**	**0.128**	ND	**0.346**	ND	**1.57**	**0.985**	0.05
	Chromium, Dissolved	ND	**0.079**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05
	Cobalt	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.048	0.027	
	Iron	15.3	3.4	1.74	12.4	1.61	1.44	22.1	1.48	ND	2.29	1.06	8.32	7.15	0.03*
	Magnesium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9.51	ND	
	Manganese	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.165	ND	0.05*
	Mercury	ND	ND	ND	ND	ND	ND	ND	ND	4E-04	ND	ND	ND	ND	
	Nickel	0.728	0.559	0.069	0.084	ND	0.262	0.158	0.701	0.025	ND	ND	0.507	0.086	
	Potassium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.26	ND	
	Sodium	51.4	39.2	42.1	14.5	63.1	44.2	50.9	46.7	67.4	49.5	44.2	43.7	34.8	
	Uranium	ND	ND	ND	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	Zinc	ND	ND	ND	0.208	0.275	ND	ND	ND	ND	ND	ND	ND	ND	
	Zinc, Dissolved	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
Rads	Alpha Activity	ND	ND	ND	13.55	ND	9.18	ND	3.53	ND	ND	ND	ND	10.8	15
(pci/L)	Beta Activity	**192.1**	20.69	32.17	**66.52**	40.62	15.88	ND	15.68	10.74	39.02	13.32	7.86	18.91	50
	Technetium-99	ND	26.4	23.3	51.2	25.9	ND	ND	ND	ND	40.3	ND	ND	ND	900
VOC	Trichloroethene	ND	ND	ND	ND	**6**	4	ND	2	**9**	**16**	**6**	**28**	5	5
(µg/L)															
Other	Alkalinity	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	125	ND	
	Silica (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13	ND	
	TOC	ND	ND	ND	1.8	ND	ND	ND	ND	1.8	ND	ND	ND	ND	
	Turbidity (NTU)	200	4.5	4.7	220	16	8.3	260	12	ND	9.2	21	55	33	
	Chloride (mg/L)	ND	ND	ND	ND	35.9	49.4	36.4	44.4	40.2	45.4	42.9	41.5	45.5	250*
	Dissolved Solids (mg/L)	312	228	236	570	590	239	264	237	287	321	294	216	307	500*
	Fluoride (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.2	ND	2.0
	Nitrate as Nitrogen (mg/L)	ND	1.6	24	ND	ND	1.7	1.1	2.1	1.6	ND	ND	1	1.3	1.0
	Sulfate (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	ND	250*

ND = Non Detect

[**Bold**] = Exceeds Kentucky MCLs

* = Secondary MCL

Table 9.3 Summary of maximum groundwater results at C-746-U

Analysis		Upgradient (MW###)		Downgradient (MW###)								
		276	**277**	**268**	**269**	**270**	**271**	**272**	**273**	**274**	**275**	**MCL**
Metal	Barium	0.242	0.229	0.181	0.066	0.143	0.161	0.224	0.191	0.211	0.206	1
(mg/L)	Barium, Dissolved	0.219	0.212	0.138	0.056	0.067	0.126	0.163	0.183	0.2	0.2	
	Cadmium	ND	ND	ND	ND	N	0.01	ND	ND	ND	ND	
	Calcium	ND	28.8	ND	ND	28.4	ND	ND	ND	ND	ND	
	Chromium	**2**	**1.21**	0.065	0.108	0.328	**0.568**	0.062	0.098	**0.673**	0.277	0.5
	Copper	ND	0.085	ND	ND	ND	ND	ND	ND	ND	ND	
	Iron	8.66	5.11	4.08	3.45	2.68	3.13	0.959	1.97	4.39	3.32	0.03*
	Manganese	ND	ND	ND	ND	0.264	ND	ND	ND	ND	ND	0.05*
	Nickel	ND	0.334	0.15	ND	ND	0.047	0.033	ND	ND	0.026	
	Sodium	35.9	31.9	35.6	48.6	44.8	40.5	55.3	36.8	42.2	37	
Rads	Alpha activity	ND	ND	ND	ND	ND	ND	ND	ND	5.22	ND	15
(pCi/L)	Beta activity	39.2	**50.89**	41.5	**142.83**	37.12	**68.9**	**161.15**	**134.55**	**186.67**	**256.86**	50
	Technetium-99	34.9	21.2	34.8	94.8	34.1	55.4	76.6	109	154	213	900
VOC (ug/L)	Trichloroethene	**20**	**17**	ND	2	ND	ND	ND	ND	ND	ND	5
Other	Chloride (mg/L)	54.3	52.5	17	30.6	27.1	25.1	62.4	37.9	41.3	37.8	250*
	Dissolved Solids (mg/L)	249	233	219	337	400	254	317	219	247	227	500*
	Fluoride (mg/L)	ND	0.17	ND	ND	0.19	ND	ND	ND	ND	ND	2
	Nitrate as Nitrogen (mg/L)	**1.1**	**1.6**	ND	**1.1**	**1.1**	**1.1**	ND	**1.1**	**1.2**	**1.3**	1
	Sulfate (mg/L)	ND	10.8	ND	ND	71.3	ND	ND	ND	ND	ND	250*
	Total Organic Halides (TOX)	ND	ND	ND	ND	490	ND	ND	ND	ND	ND	
	Turbidity (NTU)	150	28	10	18	14	13	9.7	28	18	21	

ND = Non Detect

[**Bold**] = Exceeds Kentucky MCLs

* = Secondary MCL

levels in one upgradient well and six downgradient wells. KDWM was notified of the exceedances and results were reported to KDWM on a quarterly basis. A summary of the maximum results for each parameter for the wells is provided in Table 9.3.

C-746-K Sanitary Landfill Groundwater Monitoring

The C-746-K Sanitary Landfill was used at PGDP between 1951 and 1981 primarily for the disposal of fly ash. Post-closure groundwater monitoring continues for the C-746-K Landfill on a quarterly basis. The UCRS and RGA are not present at the C-746-K site. Wells at the landfill are installed to monitor groundwater in the terrace gravels. A summary of the maximum results for each of the wells is provided in Table 9.4. Complete results of the monitoring were reported semiannually in the FFA Semiannual Progress Report.

Residential (Federal Facility Agreement) Monitoring

The FFA requires monthly sampling of residential wells potentially affected by the contaminant plume (DOE 1998). Currently, only three residential wells (R2, R294, and R302) meet this criterion. Eighteen other residential wells are monitored semiannually per the FFA. Additionally, MW66 (located on site at the northwest corner of the plant) is required to be sampled on a monthly basis. All monthly sampled wells were analyzed for alpha and beta activity, TCE, and ^{99}Tc. MW66 is sampled annually for uranium; it was not detected in 2000. As stated previously, the hydrologic unit in which residential wells are screened is uncertain; however, most are believed to be RGA wells. Table 9.5 provides a summary of the maximum detected results for the monthly monitoring programs. Semiannual residential sampling results had detections of beta, TCE, and ^{99}Tc.

Two residential wells, R424 and R432, were also sampled semiannually until July 2000. These wells contain TCE and ^{99}Tc in the groundwater below levels established by the EPA Safe Drinking Water Act, however, their location makes it highly improbable that the contaminants migrated from the Paducah Site. For R424, DOE has provided the residents with a carbon filtering system to allow them to have safe drinking water. These filters are replaced semiannually and sampled before and after filter replacement. All residents were notified by mail of the results. The filtration system for R432 has been taken out of service and the well has been locked. The resident is utilizing th municipal water supply; therefore, the well water is no longer being sampled.

Additionally, DOE sampled the groundwater wells of 23 residents that requested special sampling of their wells during 1999. These residents were also notified by mail of the results.

Environmental Surveillance Monitoring

Environmental surveillance monitoring is defined as perimeter exit pathway monitoring and off-site water well monitoring. Environmental surveillance monitoring is conducted in support of DOE orders and other laws and regulations as addressed in the *Paducah Site Environmental Monitoring Plan* (BJC 2000b). Specific wells monitored for environmental surveillance are as follows:

- *Annual Monitoring Progra*m - UCRS MWs 96, 180, 182, and 192; RGA MWs 71, 106, 134, 155, 156, 161, 163, 168, 169, 175, 178, 188, 191, 193, 200, 201, 203, 205, and 206; McNairy MW 133;

- *Annual Background Monitoring Progra*m - Terrace Gravels MW196; Eocene Sand MW305; RGA MWs 103, 150, 194, and 199; McNairy MWs 102, 120, 121, 122; and

- *Quarterly Monitoring Progra*m - UCRS MWs 166, 174, 186, and 187; RGA MWs

Table 9.4 Summary of maximum groundwater results at C-746-K

	Analysis	MW300	MW301	MW302	MW344	MCL
Metal (mg/L)	Aluminum	19.2	ND	0.203	3.68	
	Arsenic	0.009	ND	ND	0.006	0.05
	Barium	0.034	0.182	0.08	0.088	1
	Beryllium	**0.017**	ND	ND	ND	0.004
	Cadmium	ND	ND	ND	ND	0.01
	Iron	318	152	0.381	10.8	0.03*
	Lead	ND	ND	ND	ND	0.05
	Magnesium	91.9	49.8	27.8	24.4	
	Manganese	23.7	15.6	0.185	0.565	0.05*
	Nickel	0.205	ND	ND	ND	
	Potassium	16.1	23	ND	ND	
	Sodium	27.1	23.3	79	34.8	
	Strontium	1.27	0.964	0.414	0.286	
	Uranium	0.005	0.004	ND	ND	0.02
Rads (pCi/L)	Alpha activity	ND	ND	ND	7.68	15
	Beta activity	**66.1**	**63.7**	22.5	21.9	50
VOC (µg/L)	1,1,1-Trichloroethane	7	ND	ND	ND	
	1,1-Dichloroethane	80	ND	ND	ND	
	1,1-Dichloroethene	130	ND	ND	ND	
	cis-1,2-Dichloroethene	1300	17	ND	ND	
	Trichloroethene	**67**	ND	ND	ND	5
	Vinyl chloride	**11**	ND	ND	ND	2
Other	Silica (mg/L)	41	26	40	17	
	Suspended Solids (mg/L)	118	78	ND	100	

ND = Non Detect

[Bold] = Exceeds Kentucky MCLs

* = Secondary MCL

Table 9.5 Summary of maximum groundwater results from FFA monthly monitoring

Well Number	Alpha activity pCi/L	Beta activity pCi/L	^{99}Tc pCi/L	TCE µg/L
R2	11.41	610.9	663	1800
R294	ND	7.33	ND	ND
R302	3.37	11.33	ND	5
MW 66	6.04	560.22	662	1200

ND = Non Detect

Table 9.6 Summary of maximum groundwater results from environmental surveillance quarterly, annual, and background monitoring

	Parameter	Eocene	TG Well	UCRS	RGA	McNairy	Rubble Zone	MCL
VOC								
(µg/L)	1,1-Dichloroethane	ND	ND	11	9	ND	ND	
	1,1-Dichloroethene	ND	ND	ND	21	ND	ND	
	Benzene	ND	ND	7	ND	ND	ND	
	Carbon tetrachloride	ND	ND	ND	220	ND	ND	
	Chloroform	ND	ND	ND	19	ND	ND	
	cis-1,2-Dichloroethene	ND	ND	760	120	ND	ND	
	Ethylbenzene	ND	ND	5		ND	ND	
	Tetrachloroethene	ND	ND	ND	7	ND	ND	
	Trichloroethene	ND	ND	1100	**240000**	**36**	1	5
	Vinyl chloride	ND	ND	1200	**5**	ND	ND	2
Metal								
(mg/L)	Uranium	0.003	ND	0.6	0.004	0.003	0.001	
Rads								
(pCi/L)	Alpha activity	12.6	5.03	214	**146**	9.91	10.9	15
	Beta activity	17.5	7.14	**283**	**12200**	**103.76**	21	50
	Dissolved Alpha	ND	ND	209	158	8.31	ND	
	Dissolved Beta	ND	ND	274	11000	115.84	20.6	
	Neptunium-237	ND	ND	1.15	3.85	ND	2.83	
	Potassium-40	ND	ND	361	226	ND	288	
	Suspended Alpha	ND	ND	ND	3.74	13.51	ND	
	Suspended Beta	ND	ND	ND	28.1	37.15	ND	
	Technetium-99	ND	ND	81.4	13700	ND	23.8	900
	Uranium-235	ND	ND	0.531	ND	ND	ND	

ND - non detect

20, 63, 65, 98, 99, 100, 125, 135, 139, 146, 152, 165, 173, 185, 197, 202, 260, 261, 262, 328, 329, 333, 337, 338, 339, 340, 341, 342, 343, 345, 346, 347, 352, 353, 354, and 355; McNairy MW356; Rubble Zone MWs 345, 346, and 347.

During 2000, surveillance wells were sampled for VOCs, gross alpha and beta activity, and ^{99}Tc. Table 9.6 provides a summary of the maximum detected results for each hydrogeologic unit sampled for the surveillance program. The maximum TCE value reported in the RGA is 240,000 µg/L from MW156. The well is located at the southeast corner of C-400. This level of TCE is consistent with levels shown at this well in the past. TCE was also detected in the McNairy at 36 µg/L in MW356. The well was first sampled in December 1999. Only one other well completed in the McNairy (MW133) showed any TCE detections (4 µg/L).

Three wells, MW345, MW346, and MW347, have been installed penetrating the Rubble Zone, which is the formation underlying the McNairy. Initial sampling of the wells indicated no contamination. This year, TCE was detected in MW345 and MW346 at 1 µg/L. Beta was detected in all three wells: MW345 at 15.82 pCi/L, MW346 at 14.06 pCi/L, and MW347 at 20.97 pCi/L. ^{99}Tc was also detected in MW346 at 23 pCi/L and MW347 at 23.8 pCi/L.

Environmental Restoration Activities

Northwest Plume Monitoring

The EPA approved an IRA ROD to hydraulically contain off-site migration of the northwest plume. This was the first phase of remedial action for groundwater at the Paducah Site. Two extraction wells near a source of the northwest plume and two additional extraction wells farther north, near the centroid of the plume, were installed. Each set of extraction wells is surrounded by a MW network (Figure 9.10). The network is used for monitoring groundwater quality and water levels to determine the effectiveness of the interim action. Collectively, the system is known as the Northwest Plume Groundwater System.

Long-term monitoring has been conducted at the Northwest Plume. Data gathered from 1995 through 2000 suggest that the overall concentration of TCE and ^{99}Tc in the majority of the wells is decreasing. This indicates that the well fields are beginning to achieve containment of the core of the plume. Other analytical data are gathered to monitor the extraction system performance. A more detailed description of TCE and ^{99}Tc in the Northwest Plume is included in Appendix D. Summaries of the program's monitoring results are listed in Tables 9.7 and 9.8. The data for this program are reported in the FFA Semiannual Progress Report.

Northeast Plume Monitoring

A ROD was approved by the EPA in June of 1995. Implementation of the ROD was completed in 1996 and consisted of construction of two extraction wells, several MWs (Figure 9.11) and piezometers, and facilities required to transfer the TCE-contaminated water to the C-637 Cooling Tower for treatment. Groundwater quality and water level information obtained from the piezometers and MWs are used to evaluate the effectiveness of the remedial action. The upgradient MWs are used to detect possible ^{99}Tc contamination within the high-concentration area of the plume before it reaches the extraction wells.

Monitoring results from the Northeast Plume indicate TCE levels have dropped significantly since implementation of the remedial action (BJC 2001b). Other analytical data is also gathered to monitor the extraction system performance. A more detailed description of TCE and ^{99}Tc in the Northeast Plume is included in Appendix D. A summary of the program's monitoring results is listed in Table 9.9. The data for this program are reported in the FFA Semiannual Progress Report.

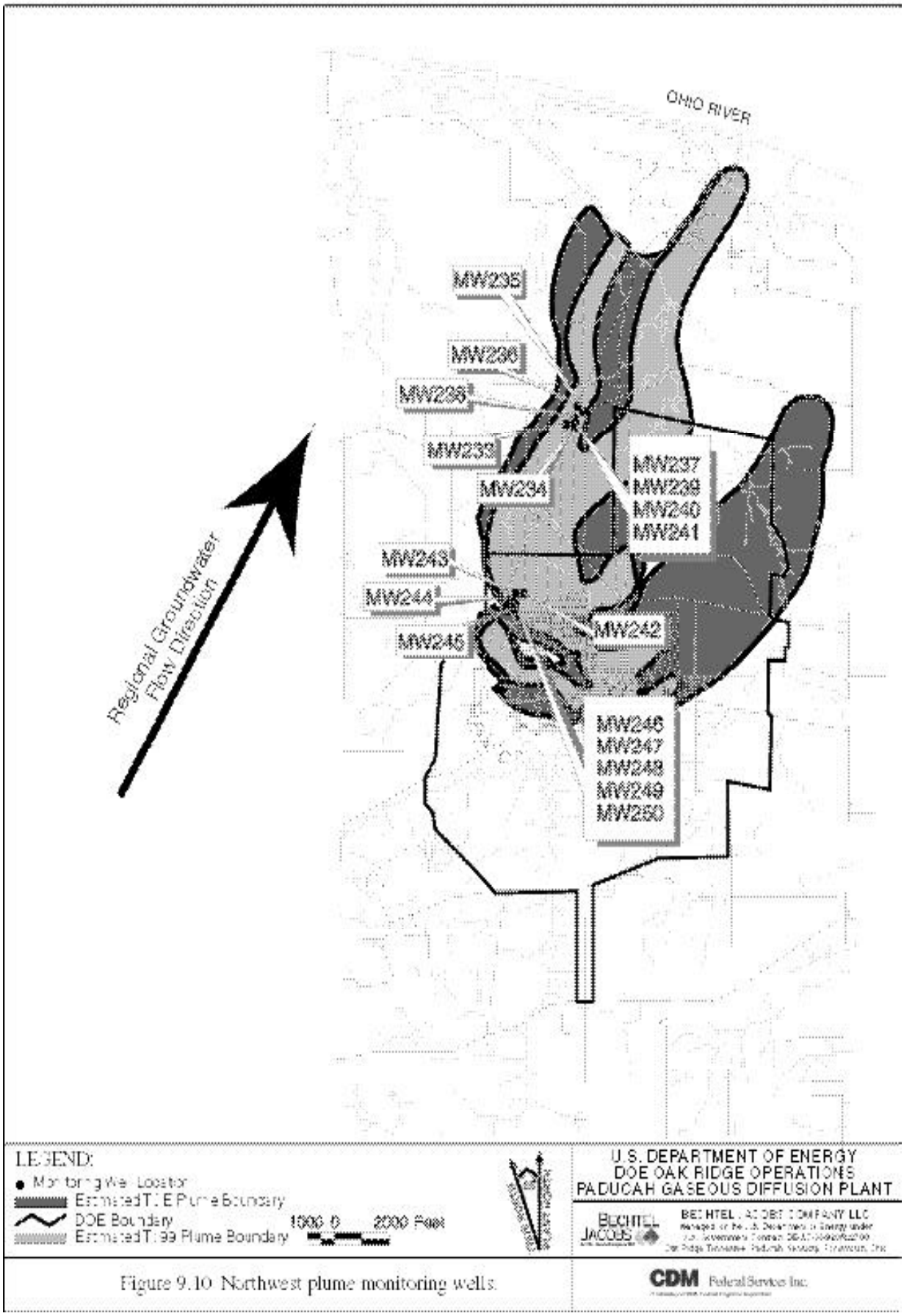

Figure 9.10 Northwest plume monitoring wells.

Table 9.7 Summary of maximum groundwater results from the Northwest Plume north field groundwater monitoring

	Analysis	MW 233	MW 234	MW 235	MW 236	MW 237	MW 238	MW 239	MW 240	MW 241
Metals										
(mg/L)	Aluminum	0.464	ND	ND	0.308	0.746	3.06	ND	0.64	3.2
	Barium	0.122	0.16	0.161	0.15	0.3	0.137	0.042	0.133	0.144
	Barium, Dissolved	0.124	0.162	0.162	0.147	0.292	0.135	0.042	0.134	0.132
	Calcium	19.2	22.8	24.3	23.7	20.6	22	5.6	23.1	21.6
	Calcium, Dissolved	16.8	20.8	21.8	20.2	18.4	19.5	4.38	19	18.2
	Chromium	0.038	0.09	0.097	0.043	ND	ND	ND	ND	ND
	Iron	1.47	3.19	1.62	1.23	0.966	5.2	26.4	2.62	7.43
	Iron, Dissolved	ND	ND	ND	ND	ND	ND	21.1	ND	ND
	Magnesium	7.88	9.32	9.94	9.65	8.15	9.16	3.4	9.31	8.9
	Magnesium, Dissolved	7.08	8.73	9.25	8.51	7.67	8.28	2.87	8.13	7.89
	Manganese	0.044	ND	ND	ND	ND	0.06	0.906	0.06	0.178
	Manganese, Dissolved	0.044	ND	ND	ND	ND	ND	0.823	ND	ND
	Nickel	0.084	ND	ND	ND	ND	ND	ND	ND	ND
	Nickel, Dissolved	0.114	ND	ND	ND	ND	ND	ND	ND	ND
	Potassium	ND	ND	ND	ND	ND	ND	8.23	ND	ND
	Potassium, Dissolved	ND	ND	ND	ND	ND	ND	7.23	ND	ND
	Sodium	27.7	32.4	34.3	32.8	72.3	29.1	19.9	28.1	27.7
	Sodium, Dissolved	25.1	28.9	30.6	28.4	63	25.5	16.9	24.4	23.3
Rads										
(pCi/L)	Alpha activity	ND	ND	9.1	14.32	7.24	8.14	6.06	7	9.85
	Beta activity	88.49	810.71	399.26	662.03	27.11	573.32	27.44	495.58	288.56
	Technetium-99	97.8	859	550	622	ND	569	ND	679	350
VOC										
(µg/L)	Trichloroethene	170	1800	1200	1500	4	1100	ND	1200	710
Other	Dissolved Solids (mg/L)	169	202	217	198	305	178	173	183	165
	Chloride (mg/L)	25.1	36.2	40.4	32.5	9.7	26.4	22.2	26.8	25
	Fluoride (mg/L)	0.16	0.14	0.14	0.15	0.52	0.15	0.31	0.15	0.15
	Nitrate as Nitrogen (mg/L)	1.7	2.3	2.4	2.6	1	1.9	ND	1.9	1.7
	Sulfate (mg/L)	13.5	19.2	17.8	20.6	33.7	21.5	18	19.7	20.2
	Alkalinity (mg/L)	80	85	91	83	191	81	56	83	82
	Silica (mg/L0	25	18	23	21	43	23	42	23	21
	Total Phosphate as Phosphorous (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Turbidity (NTU)	19	15	10	12	50	160	80	18	90

ND = Non Detect

Table 9.8 Summary of maximum groundwater results from the Northwest Plume south field groundwater monitoring

	Parameter	MW 242	MW 243	MW 244	MW 245	MW 246	MW 247	MW 248	MW 249	MW 250
Metal (mg/L)	Aluminum	1.64	ND	ND	9.45	1.79	ND	0.496	2.35	0.238
	Aluminum, Dissolved	ND	ND	ND	0.753	ND	ND	ND	ND	ND
	Barium	0.269	0.158	0.099	0.19	0.043	0.134	0.134	0.096	0.099
	Barium, Dissolved	0.283	0.168	0.105	0.17	0.039	0.116	0.135	0.099	0.106
	Calcium	31	30.4	21.7	22.1	36	23.7	28.6	20.6	22.2
	Calcium, Dissolved	26.2	27.1	18.4	19.1	30.2	18.8	24.5	19.2	19.6
	Chromium	0.11	0.039	0.098	ND	ND	ND	ND	ND	ND
	Copper	0.029	0.032	0.031	0.031	0.027	0.126	0.029	ND	0.028
	Iron	6.81	2.64	0.778	11.4	1.08	3.15	1.27	3.77	0.407
	Iron, Dissolved	ND	ND	ND	0.416	ND	ND	ND	ND	ND
	Magnesium	12.4	12.4	9.57	9.21	15.9	12.4	11.9	8.67	9.22
	Magnesium, Dissolved	11.3	11.4	8.24	7.81	13.5	12	11	8.07	8.83
	Manganese	0.203	0.056	0.035	2.12	ND	0.636	0.996	0.208	ND
	Manganese, Dissolved	0.131	0.029	ND	1.07	ND	0.369	ND	ND	ND
	Nickel	0.866	0.139	0.464	ND	ND	ND	ND	ND	ND
	Nickel, Dissolved	0.842	0.123	0.403	ND	ND	ND	ND	ND	ND
	Potassium	ND	ND	ND	ND	ND	6.43	ND	ND	ND
	Potassium, Dissolved	ND	ND	ND	ND	ND	5.76	ND	ND	ND
	Sodium	28.2	28.9	33.5	24.6	105	37	26.1	26.2	33.8
	Sodium, Dissolved	22.6	25.5	29.2	20.4	92.8	33.3	20.5	22	29.1
Rads (pCi/L)	Alpha activity	ND	ND	ND	ND	6.73	ND	ND	ND	ND
	Beta activity	106.07	249.61	34.03	47.92	24.44	8.27	1263	42.91	42.75
	Radium	ND	ND	ND	ND	ND	0.67	ND	ND	ND
	Radon	ND	208	ND	269	1080	ND	291	ND	ND
	Technetium-99	115	253	53.9	54.8	ND	ND	1430	39.2	63.8
	Thorium-230	ND	ND	ND	2.82	ND	ND	ND	ND	ND
VOC (ug/L)	Trichloroethene	180	610	5	110	2	ND	7800	61	28
Other	Dissolved Solids (mg/L)	222	225	194	155	464	183	185	146	185
	Chloride (mg/L)	66.1	67.4	37	10.3	11.7	4.4	55.5	18.6	36.6
	Fluoride (mg/L)	ND	0.14	0.14	0.18	0.28	0.14	0.1	0.12	0.14
	Nitrate as Nitrogen (mg/L)	1.3	1.5	1.5	ND	ND	ND	3.2		1.3
	Sulfate (mg/L)	10.8	10.7	10.1	10.4	186.2	ND	8.9	9.1	11.3
	Alkalinity (mg/L)	78	72	87	92	150	183	71	75	93
	Silica (mg/L)	18	17	35	26	38	4	19	20	20
	Total Phosphate as Phosphorous (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Turbidity (NTU)	75	16	5.5	210	14	26	19	55	5.6
	TOC (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Non Detect

Groundwater Monitoring Results

The primary objectives of groundwater monitoring at the Paducah Site are being met by the monitoring program. Contamination has been detected in groundwater off-site. Through the monitoring program, in conjunction with RIs, a footprint of the groundwater contamination has been mapped and is regularly updated. The program continues to expand each year to further delineate the boundaries of the footprint over time and to identify source locations for contaminants. Monitoring wells upgradient and downgradient from individual underground waste disposal facilities are sampled and analyzed for Contaminants of Concern (COCs). Contaminants identified by the monitoring program are evaluated by technical assessment and statistical analysis to determine if the source of the contaminants could be the disposal site being monitored. ^{99}Tc, beta activity, and TCE are found in the off-site and on-site contamination plumes. Chromium and dissolved solids are also present in some wells, although these contaminants are thought to be natural in origin and not a result of past practices. Groundwater monitoring results from all sampling efforts conducted by the Paducah Site are compiled in the Paducah Oak Ridge Environmental Information System (OREIS) database. A complete listing of analytical results is available upon request from the BJC Public Affairs Department.

Appendix D contains a more detailed interpretation of the TCE and ^{99}Tc groundwater contamination and plumes within the RGA. Detailed plume figures are included in *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2000 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001) have been omitted from this report due to space limitations. However, Figure 9.1 shows offsite groundwater plumes. The complete report is available from the DOE EIC.

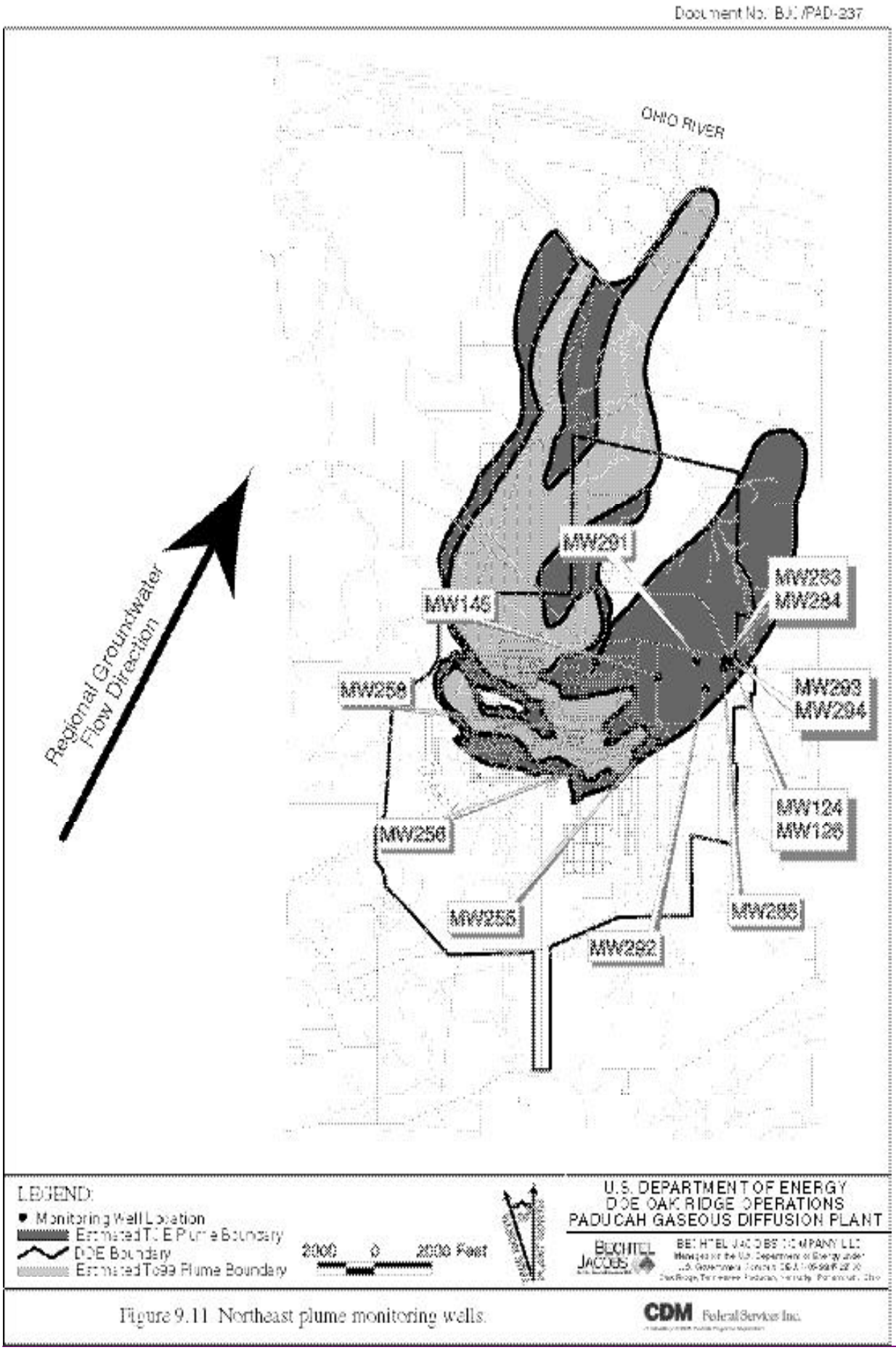

Figure 9.11 Northeast plume monitoring wells.

Table 9.9 Summary of maximum groundwater results from the Northeast Plume groundwater monitoring

		Monitoring Well (MW####)												
Parameter		**124**	**126**	**145**	**255**	**256**	**258**	**283**	**284**	**288**	**291**	**292**	**293**	**294**
Metal	Aluminum	ND	ND	ND	0.882	ND	ND	ND	ND	ND	0.781	ND	ND	ND
(mg/L)	Barium	0.233	0.221	0.076	0.191	0.289	0.228	0.268	0.275	0.256	0.26	0.24	0.177	0.225
	Barium, Dissolved	0.226	0.197	0.052	0.174	0.192	0.197	0.266	0.267	0.224	0.243	0.168	0.119	0.217
	Calcium	24.4	24.1	51.3	31.7	27.7	29.4	26.1	25.9	30.3	23.6	29.1	24.5	23.3
	Calcium, Dissolved	24.7	23.4	52.2	30.6	26.8	28.3	26.3	25.5	30.9	23.5	27	24.4	22.7
	Chromium	0.348	1.02	0.108	0.137	0.062	0.537	0.04	0.277	0.398	0.492	0.244	0.098	0.256
	Iron	4.2	8.04	0.409	1.43	0.346	4.47	0.244	1.26	2.69	3.23	1.44	0.807	1.09
	Magnesium	9.43	9.12	20.3	12.2	10.7	11.2	10.3	10.2	12.2	9.27	11.6	8.72	9.26
	Magnesium, Dissolved	9.39	8.81	18.7	11.7	7.46	10.7	10.3	10	12.2	9.1	11	6.83	8.95
	Manganese	0.025	0.045	ND	0.111	ND	ND	ND	ND	ND	0.059	0.047	ND	ND
	Manganese, Dissolved	ND	ND	ND	0.075	ND	ND	ND	ND	ND	0.035	0.043	ND	ND
	Nickel	0.067	0.065	ND	0.101	ND	0.062	ND	ND	ND	0.07	0.312	0.17	ND
	Nickel, Dissolved	ND	ND	ND	0.082	ND	0.065	ND	ND	ND	ND	0.217	0.082	ND
	Potassium	ND	ND	5.1	2.07	ND	2.06	ND	ND	ND	ND	ND	ND	ND
	Potassium, Dissolved	ND	ND	4.83	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Sodium	46	45.8	64.2	85.4	58.5	71.4	36.1	39.3	43.6	38.9	51.8	33.8	39.8
	Sodium, Dissolved	46.5	44.5	61.1	83.4	42.5	67.7	37.2	37	44.3	38.7	48.8	28.5	39.2
Rads	Beta activity	55.74	ND	31.48	16.25	117.39	14.93	7.44	23.56	23.34	9.09	19.5	ND	5.5
(pCi/L)	Technetium-99	ND	ND	ND	ND	96.2	17.3	ND	18.3	26.3	ND	15.9	ND	ND
VOC (ug/L)	1,1-Dichloroethene	ND	ND	ND	ND	81	ND	ND	ND	ND	ND	ND	ND	ND
	cis-1,2-Dichloroethene	ND	ND	7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Trichloroethene	720	110	120	1400	390	1100	210	250	1100	240	960	320	810
Other	Dissolved Solids (mg/L)	237	234	425	350	266	317	232	226	273	228	252	218	219
	Chloride (mg/L)	65.2	59.5	103.5	70.5	57	70	62.7	67.4	74.6	63.3	73.8	55.8	65.1
	Fluoride (mg/L)	0.14	0.15	0.14	0.2	0.19	0.18	0.12	0.12	0.13	0.14	0.16	0.14	0.13
	Nitrate as Nitrogen (mg/L)	1.7	1.4	ND	1.1	ND	1.5	1.2	1.3	1.3	1.5	1.6	1.7	1.7
	Sulfate (mg/L)	12.5	11.7	82.4	35.7	20.9	19.7	8.6	5.8	16.5	19.7	10.9	11.4	6.7
	Alkalinity (mg/L)	93	93	134	175	142	137	85	78	98	80	113	77	10
	Silica (mg/L)	14	15	15	13	13	14	15	14	14	14	14	13	14
	Total Organic Carbon (TOC)	ND	ND	1.2	1.2	1	1	ND	ND	ND	ND	ND	1.5	ND
	Phosphate as Phosphorous (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Turbidity (NTU)	16	19	2	19	1.8	28	1.6	8.1	17	23	11	4.2	3.6

ND = Non Detect

10 Quality Assurance

Abstract

The Paducah Site maintains a Quality Assurance/Quality Control (QA/QC) Program to verify the integrity of data generated within the environmental monitoring program. Monitoring and sampling organizations at Paducah select sampling methods, instruments, locations, schedules, and other sampling and monitoring criteria based on applicable guidelines from various established authorities.

Introduction

The Paducah Site maintains a QA/QC Program to verify the integrity of data generated within the Environmental Monitoring Program. Each aspect of the monitoring program, from sample collection to data reporting, must address quality requirements and assessment standards. Requirements and guidelines for the QA/QC Program at the Paducah Site are established by DOE Order 414.1, *Quality Assurance*; state and federal regulations; and documentation from EPA, the American National Standards Institute, the American Society of Mechanical Engineers, the American Society of Testing and Materials (ASTM), and the American Society for Quality Control. The QA/QC Program specifies organizational and programmatic elements to control equipment, design, documents, data, nonconformances, and records. Emphasis is placed on planning, implementing, and assessing activities.

The *Environmental Services Subcontract Quality Assurance and Data Management Plan* (CDM 1999) [EQADMP] defines the relationship of each element of the Environmental Monitoring Program to key quality and data management requirements. Training requirements, sample custody, procedures, instrument calibration and maintenance, and data review are a few of the subjects discussed in the EQADMP. In 2000, a variety of functions were performed for the Environmental Monitoring Program such as developing DQOs, conducting surveillances, reporting problems, reviewing data, reviewing procedures, and revising the EQADMP.

Field Sampling Quality Control

Data Quality Objectives and Sample Planning

From the point of conception of any sampling program, DQOs play an important role. The number of samples, location of sampling sites,

sampling methods, sampling schedules, and coordination of sampling and analytical resources to meet critical completion times are part of a DQO process and are documented in the *Paducah Site Environmental Monitoring Plan* (BJC 2000a).

Each sample location and sample collected is assigned a unique identification number, which consists of an alphanumeric sequence. Each segment of the sequence is used to designate information concerning the location from which a sample is collected. In order to progress from planning to implementing the DQOs, an analytical statement of work (SOW) for the analytical laboratory is generated from a system within the Paducah Integrated Data System. From this system, the Project Environmental Measurements System (PEMS), an electronic database used for streamlining field-generated and laboratory-generated data, is populated with sample identification numbers, sampling locations, sampling methods, analytical parameters, analytical methods, and container and preservative requirements. This information is used to produce sample bottle/jar labels and chain-of-custody forms for the sampling event.

Field Measurements

Field measurements for the groundwater and surface water monitoring program are collected real-time in the field and consist of water level measurements, pH, conductivity, flow rates, turbidity, temperature, dissolved oxygen, total residual chlorine, and barometric pressure. Environmental conditions such as temperature and weather are also recorded. Field measurements are collected and either downloaded electronically, recorded on appropriate field forms, or recorded in logbooks, and input into PEMS on a weekly or other appropriate basis.

Sampling Procedures

Samples are collected using media-specific procedures, which are written according to EPA-approved sampling methods. Sample media consist of surface water, groundwater, sediment, and biota, such as fish or deer. Sample information collected during a sample event consist of the following: sample identification number, station (or location), date collected, time collected, person who performed the sampling, etc. This information is recorded in the logbooks and on the chain-of-custody form and sample container label, and input directly into PEMS on a weekly or other appropriate basis. Chain-of-custody forms are maintained from the point of sampling, and samples are properly protected until they are placed in the custody of an analytical laboratory.

Field Quality Control Samples

The QC program for both groundwater and environmental monitoring activities specify a minimum target rate of 5%, or one per 20 environmental samples, on field QC samples. Table 10.1 shows the types of field QC samples collected and analyzed. Analytical results of field QC samples are evaluated to determine if the sampling event had, in some way, affected the sample results.

Analytical Laboratory Quality Control

Analytical Procedures

When available and appropriate for the sample matrix, SW-846 methods are used for sample analysis. When SW-846 methods are not available, other nationally recognized methods such as those of DOE, EPA, and ASTM are used. Analytical methods are identified in an analytical SOW. Using guidance from EPA, the laboratories document the steps in handling, analysis, and approval of results. Chain-of-custody procedures are followed until a sample is analyzed.

Table 10.1 Types of quality control (QC) samples

Field QC Samples	Laboratory QC Samples
Field blanks	Laboratory duplicates
Field duplicates	Reagent blanks
Trip blanks	Matrix spikes
Equipment rinseates	Matrix spike duplicates
	Surrogates
	Performance evaluations
	Laboratory control samples

Laboratory Quality Control Samples

Laboratory QC samples are prepared and analyzed as required by the analytical methods used. Typical laboratory QC samples are identified in Table 10.1. If acceptance criteria are not met for the QC samples, then appropriate action, as denoted by the analytical method, is taken or appropriate qualification of the data occurs.

Independent Quality Control

The Paducah Site is directed by DOE and EPA to participate in independent QC programs. The site also participates in voluntary independent programs to improve analytical QC. These programs generate data that are readily recognizable as objective measures, allowing participating laboratories and government agencies a periodic review of their performance. Results that exceed acceptable limits are investigated and documented according to formal procedures. Although participation in certain programs is mandated, the degree of participation is voluntary so that each laboratory can select parameters of particular interest to that facility. These programs are conducted by EPA, DOE, and commercial laboratories.

Laboratory Audits/Sample Management Office

Laboratory audits are performed periodically by the BJC Oak Ridge Sample Management Office (SMO) to ensure the laboratory is in compliance with regulations, procedures, and the contract between the laboratory and the SMO. Findings are documented and addressed by the audited laboratory through corrective actions.

Data Management

Project Environmental Management System

The data generated are stored in PEMS, a consolidated site data system for tracking and managing data. The system is used to manage field-generated data; import laboratory-generated data; input data qualifiers identified during the data review process; and transfer data to the Paducah

OREIS for reporting. PEMS uses a variety of references and code lists to ensure consistency and standardize the presentation of data for users.

Electronic Data Deliverables

A "results only" Eletronic Data Deliverable (EDD) is requested for all samples analyzed by each laboratory. The results and qualifier information from the EDD are checked in addition to the format of all fields provided. Discrepancies are immediately reported to the laboratory so corrections can be made or new EDDs can be issued. A random sample, consisting of approximately 10% of the EDDs are checked to verify that the laboratory continues to provide adequate EDDs.

Data Packages

A "forms only" Level III data package is requested from the laboratory when data validation is to be performed on a specific sampling event or media. All data packages received from the fixed-base laboratory are tracked, reviewed, and maintained in a secure environment. The following information is tracked: sample delivery group number; date received; number of samples; sample analyses; receipt of the EDD, if applicable; and comments. The contents of the data package and the chain-of-custody forms are compared and discrepancies are identified. Discrepancies are immediately reported to the laboratory and data validators. All data packages are forwarded to the PGDP Environmental Management and Enrichment Facilities Document Management Center for permanent storage.

Laboratory Contractual Screening

Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical SOW to ensure that all requested information is received. The contractual screening includes, but is not limited to, the chain-of-custody form, number of samples, analytes requested, total number of analyses, method used, QC samples analyzed, EDDs, units, holding times, and reporting limits achieved. The contractual screening is conducted electronically upon receipt of data from the analytical laboratory. Any exception to the SOW is identified and documented.

Data Verification, Validation, and Assessment

Data verification is the process for comparing a data set against a set standard or contractual requirement. Verification is performed electronically, manually, or by a combination of both. Data verification includes contractual screening and other criteria specific to the data. Data are flagged as necessary. Verification qualifiers are stored in PEMS and transferred with the data to Paducah OREIS.

Data validation is the process performed by a qualified individual for a data set, independent from sampling, laboratory, project management, or other decision-making personnel. Data validation evaluates the laboratory adherence to analytical method requirements. Validation qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data are validated programmatically at a frequency of 5% of the total data packages from routine sampling events. Each data package is validated 100%.

Data assessment is the process for assuring that the type, quality, and quantity of data are appropriate for their intended use. It allows for the determination that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100% to ensure data are useable. The data assessment is conducted by trained technical personnel or their designee in conjunction with other project team members. Assessment qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting from Paducah OREIS upon completion of the data assessment,

and associated documentation is filed with the project files.

Paducah OREIS

Paducah OREIS is the database used to consolidate data generated by the Environmental Management Program. Data consolidation consists of the activities necessary to prepare the evaluated data for the users. The PEMS files containing the assessed data are transferred from PEMS to Paducah OREIS for future use. The data manager is responsible for notifying project team and other data users of the data availability. Data used in reports distributed to external agencies (e.g., the quarterly landfill reports, the ASER, and the biological monitoring program reports) are obtained from Paducah OREIS and have been through the data review process.

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Glossary

absorption – The process by which the number and energy of particles or photons entering a body of matter is reduced by interaction with the matter.

activity – See radioactivity.

air stripping – The process of bubbling air through water to remove volatile organic compounds from the water.

alpha particle – A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air – The atmosphere around people, plants, and structures.

analyte – A constituent or parameter being analyzed.

analytical detection limit – The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer – A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquitard – A geologic unit that inhibits the flow of water.

assimilate – To take up or absorb.

atom – Smallest particle of an element capable of entering into a chemical reaction.

beta particle – A negatively charged particle emitted from the nucleus of an atom. It has a mass and charge equal to those of an electron.

biota – The animal and plant life of a particular region considered as a total ecological entity.

CERCLA-reportable release – A release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

chain of custody form – A form that documents sample collection, transport, analysis, and disposal.

closure – Formal shutdown of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

compliance – Fulfillment of applicable requirements of a plan or schedule ordered or approved by government authority.

concentration – The amount of a substance contained in a unit volume or mass of a sample.

conductivity – A measure of a material's capacity to convey an electric current. For water this property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence – The point at which two or more streams meet; the point where a tributary joins the main stream.

congener – Any particular member of a class of chemical substances. A specific congener is denoted by a unique chemical structure.

contained landfill – A solid waste site or facility that accepts disposal of solid waste. The technical requirements for contained landfills are found in 401 KAR 47:080, 48:050, and 48:070 to 48:090.

contamination – Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation – Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation is one contributor to natural background radiation.

curie (Ci) – A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used:

- **kilocurie (kCi)** – 10^{3} Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
- **millicurie (mCi)** – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
- **microcurie (µCi)** – 10^{-6} Ci, one-millionth of a curie; 3.7×10^{4} disintegrations per second.
- **picocurie (pCi)** – 10^{-12} Ci, one-trillionth of a curie; 3.7×10^{-2} disintegrations per second.

daughter – A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive – The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide or into a different energy state of the same radionuclide.

dense nonaqueous phase liquid (DNAPL) – The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethylene and trichloroethylene.

derived concentration guide (DCG) – The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in either an effective dose equivalent of 0. 1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and the lens of the eye. The guidelines for radionuclides in air and water are given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

disintegration, nuclear – A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

dose – The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joules per kilogram in any medium.

- **absorbed dose** – The quantity of radiation energy absorbed by an organ divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 Gy).
- **dose equivalent** – The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 Sv).
- **committed dose equivalent** – The calculated total dose equivalent to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed dose equivalent is expressed in units of rem (or sievert).
- **committed effective dose equivalent** – The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting

factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

- **effective dose equivalent** – The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.
- **collective dose equivalent/collective effective dose equivalent** – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

downgradient – In the direction of decreasing hydrostatic head.

downgradient well – A well that is installed hydraulically downgradient of a site and that may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS) – Federal primary drinking water standards, both proposed and final, as set forth by the EPA in 40 CFR 141 and 40 CFR 143.

effluent – A liquid or gaseous waste discharge to the environment.

effluent monitoring – The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.

Environmental Restoration – A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities (decontamination and decommissioning) contaminated with waste as a result of nuclear-related activities.

exposure (radiation) – The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is that exposure to ionizing radiation received at a person's workplace. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation – Exposure to ionizing radiation when the radiation source is located outside the body.

fauna – The population of animals in a given area, environment, formation, or time span.

flora – The population of plants in a given area, environment, formation, or time span.

formation – A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

gamma ray – High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are indentical to X-rays except for the source of the emission.

Gaussian puff/plume model – A computer-simulated atmospheric dispersion of a release

using a Gaussian (normal) statistical distribution to determine concentrations in air.

grab sample – A sample collected instantaneously with a glass or plastic bottle placed below the water surface to collect surface-water samples (also called dip samples).

groundwater, unconfined – Water that is in direct contact with the atmosphere through open spaces in permeable material.

half-life, radiological – The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life.

hardness – The amount of calcium carbonate dissolved in water, usually expressed as part of calcium carbonate per million parts of water.

hydrogeology – Hydraulic aspects of site geology.

hydrology – The science dealing with the properties, distribution, and circulation of natural water systems.

in situ – In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor – A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation – Occurs when natural radionuclides enter the body by ingestion of foods, milk, or water or by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion – An atom or compound that carries an electrical charge.

irradiation – Exposure to radiation.

isotopes – Forms of an element having the same number of protons but differing numbers of neutrons in their nuclei.

- **long-lived isotope** – A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).

- **short-lived isotope** – A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

lower limit of detection – The smallest concentration or amount of analyte that can be reliably detected in a sample at a 95% confidence level.

maximally exposed individual – A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose equivalent.

migration – The transfer or movement of a material through air, soil, or groundwater.

milliroentgen (mR) – A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable concentration – The smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given

measurement system at a preselected counting time and at a given confidence level.

monitoring – Process whereby the quantity and quality of factors that can affect the environment or human health are measured periodically to regulate and control potential impacts.

mrem – The dose equivalent that is one-thousandth of a rem.

natural radiation – Radiation from cosmic and other naturally occurring radionuclide (such as radon) sources in the environment.

nuclide – An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

outfall – The point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

part per billion (ppb) – A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or mg/mL.

part per million (ppm) – A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

pathogen – A disease-producing agent; usually refers to living organisms.

person-rem – Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH – A measure of the hydrogen-ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 6, neutral solutions have a pH equal to 7, and basic solutions have a pH greater than 7.

piezometer - An instrument used to measure the hydraulic potential of groundwater at a given point; also, a well designed for this purpose.

polychlorinated biphenyl (PCB) - Any chemical substance that is limited to the biphenyl molecule and that has been chlorinated to varying degrees.

polynuclear aromatic hydrocarbon (PAH) - Any organic compound composed of more than one benzene ring.

process water - Water used within a system process.

purge - To remove water before sampling, generally by pumping or bailing.

quality assurance (QA) - Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC) - The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes.

quality factor - The factor by which the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. A quality factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad - An acronym for Radiation Absorbed Dose. The rad is a basic unit of absorbed radiation dose.

(This is being replaced by the 'gray,' which is equivalent to 100 rad.)

radiation detection instruments – Devices that detect and record the characteristics of ionizing radiation.

radioactivity – The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radioisotopes – Radioactive isotopes.

radionuclide – An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reference material – A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

release – Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem – The unit of dose equivalent (absorbed dose in rads multiplied by the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation – The correction of a problem. See Environmental Restoration.

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

RFI Program – RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

roentgen – A unit of exposure from X-rays or gamma rays. One roentgen equals 2.58 x 10^4 coulombs per kilogram of air.

screen zone – In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

semivolatile organic analyte (SVOA) – Any organic compound with a high boiling point which will volatilize upon heating.

sievert (Sv) – The SI (International System of Units) unit of dose equivalent; 1 Sv = 100 rem.

slurry – A suspension of solid particles (sludge) in water.

source – A point or object from which radiation or contamination emanates.

specific conductance – The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

stable – Not radioactive or not easily decomposed or otherwise modified chemically.

storm water runoff – Surface streams that appear after precipitation.

strata – Beds, layers, or zones of rocks.

substrate – The substance, base, surface, or medium in which an organism lives and grows.

surface water – All water on the surface of the earth, as distinguished from groundwater.

suspended solids – Mixture of fine, nonsettling particles of any solid within a liquid or gas.

terrestrial radiation – Ionizing radiation emitted from radioactive materials, primarily ^{40}K, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

thermoluminescent dosimeter (TLD) – A device used to measure external gamma radiation.

total activity – The total quantity of radioactive decay particles that are emitted from a sample.

total solids – The sum of total dissolved solids and suspended solids.

total suspended particulates – Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transuranic element (TRU) – An element above uranium in the Periodic Table, that is, with an atomic number greater than 92. All 11 TRUs are produced artificially and are radioactive. They are neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and lawrencium.

troughing system – A collection and containment system designed to collect leaks of oil that have been contaminated with PCBs.

turbidity – A measure of the concentration of sediment or suspended particles in solution.

upgradient – In the direction of increasing hydrostatic head.

vadose zone – Soil zone located above the water table.

volatile organic compound (VOC) – Any organic compound which has a low boiling point and readily volatilizes into air (e.g., trichloroethane, tetrachloroethylene, and trichloroethylene).

watershed – The region draining into a river, river system, or body of water.

wetland – A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted to life in saturated soils.

wind rose – A diagram in which statistical information concerning direction and speed of the wind at a location is summarized.

Appendix A: Radiation

This appendix gives basic facts about radiation. This information is intended as a basis for understanding normal radiation dose from sources unassociated with the Paducah Site. The McGraw-Hill dictionary defines radiation and radioactivity as follows:

radiation - 1. The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. 2. The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic radiation. Also known as radiant energy. 3. A stream of particles, such as electrons, neutrons, protons, alpha particles, or high-energy photons, or a mixture of these (McGraw-Hill 1994).

radioactivity - A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1994).

Radiation occurs naturally; it was not invented, but rather, was discovered. People are constantly exposed to radiation. For example, radon in air; potassium in food and water; and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types, sources, and pathways of radiation; radiation measurement; and dose information.

ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of matter consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (ANS 1986). The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element with a different number of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights. Figure A.1 depicts isotopes of the element hydrogen. Another example is the element uranium, which has 92 protons; all isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. ^{234}U has 92 protons and 142 neutrons; ^{235}U has 92 protons and 143 neutrons; and ^{238}U has 92 protons and 146 neutrons.

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called radioisotopes, or radionuclides. In an attempt to become stable, radionuclides "throw away" or emit rays or particles. This emission of rays and particles is known as radioactive decay.

RADIATION

Radiation, or radiant energy, is energy in the form of waves or particles moving through space.

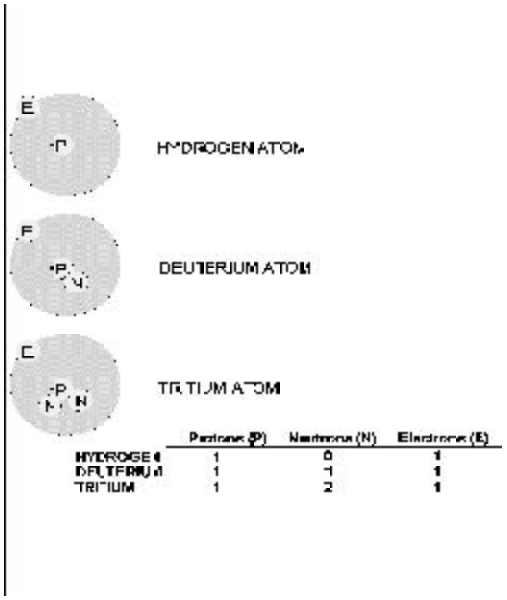

Figure A.1 Isotopes of the element hydrogen

Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is radiation in the form of electromagnetic waves; examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles; examples include alpha and beta particles. Radiation also is characterized by the way it interacts with matter.

Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some forms of radiation can ionize atoms by "knocking" electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation. Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage, making it potentially harmful to human health. Figure A.2 shows the penetrating potential of different types of ionizing radiation.

Nonionizing Radiation

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. Currently, it is unclear whether nonionizing radiation is harmful to human health. In the discussion that follows, the term radiation is used to describe ionizing radiation.

SOURCES OF RADIATION

Radiation is everywhere. Most occurs naturally, but a small percentage is from human-made sources. Naturally occurring radiation is known as background radiation.

Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Though people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time; background radiation present in the environment today is much the same as it was hundreds of years ago.

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as cosmic, terrestrial, or internal, depending on its origin.

Cosmic Radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere.

These particles and the secondary particles and photons they create are called cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. In other words, a person in Denver, Colorado, is exposed to more cosmic radiation than a person near Paducah, Kentucky.

Terrestrial Radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-235 (^{235}Ra); potassium (^{40}K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

Internal Radiation

Radioactive material in the environment enters the body through the air people breathe and the food they eat; it also can enter through an open wound. Natural radionuclides in the body include isotopes of U, Th, radium, Rn, polonium, bismuth, and lead in the ^{238}U and Thorium-212 decay series. In addition, the body contains isotopes of ^{40}K , rubidium, and carbon.

Human-Made Radiation

In addition to background radiation, there are human-made sources of radiation to which most people are exposed. Examples include consumer products, medical sources, and fallout from atmospheric atomic weapons tests. (Atmospheric testing of atomic weapons has been suspended.) Also, about one-half of 1% of the United States population performs work in which radiation in some form is present.

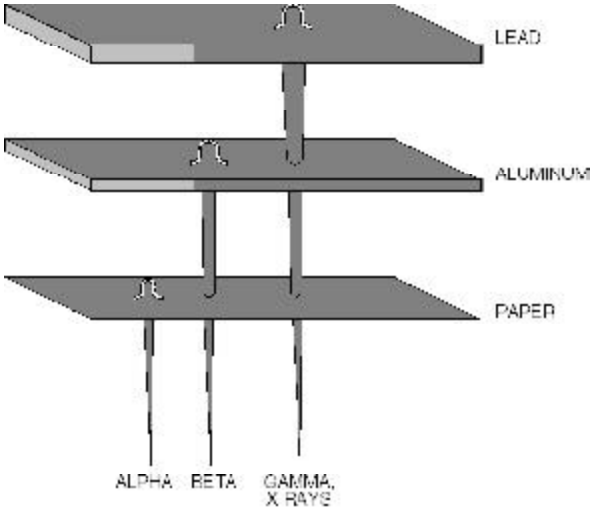

Figure A.2. Penetrating power of radiation.
Some types of radiation can be easily shielded against. For example, a sheet of paper is sufficient to stop an alpha particle. Gamma rays can pass through paper but can be stopped by the appropriate amount of lead. Radiation's ability to penetrate is an important consideration in protecting human health. Adequate shielding decreases the power of radiation by absorbing part or all of it.

Consumer Products

Some consumer products are sources of radiation. In some of these products, such as smoke detectors and airport X-ray baggage inspection systems, the radiation is essential to the performance of the device. In other products, such as televisions and tobacco products, the radiation occurs incidentally to the product function.

Medical Sources

Radiation is an important tool of diagnostic medicine and treatment and, in this use, is the main source of exposure to human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. Generally, diagnostic or therapeutic medical exposures result from X- ray beams directed to specific areas of the body. Thus, all body organs generally are not irradiated

uniformly. Radiation and radioactive materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medicine examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body.

Other Sources

Other sources of radiation include fallout from atmospheric atomic weapons tests; emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; emissions from mineral extraction facilities; and transportation of radioactive materials.

PATHWAYS OF RADIATION

Radiation and radioactive material in the environment can reach people through many routes. Potential routes for radiation are referred to as pathways (Figure A.3). For example, radioactive material in the air could fall on a pasture. The grass could then be eaten by cows, and the radioactive material on the grass would show up in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or, people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed; people eating the fish would then be exposed to the radiation in the fish. Or, people swimming in the water would be exposed.

MEASURING RADIATION

To determine the possible effects of radiation on the environment and the health of people, the radiation must be measured. More precisely, its potential to cause damage must be determined.

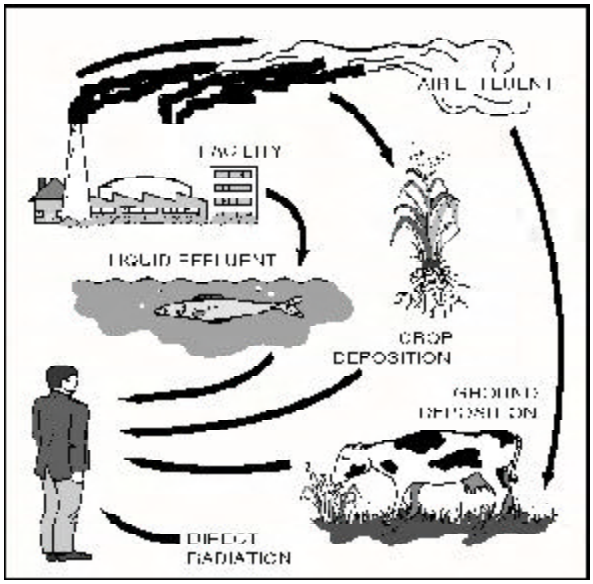

Figure A.3 Possible radiation pathways.

Activity

When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radioisotopes. For that reason, 1 g of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, 1 Ci = 3.7E+10 (37,000,000,000) atom disintegrations per second (dps). In the international system of units, 1 dps = 1 becquerel (Bq).

Absorbed Dose

The total amount of energy absorbed per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a rad. In the international system of units, 100 rad = 1 gray. However, in terms of human health, it is the effect of the absorbed energy that is important because some forms of radiation are more harmful than others as a result of their energy deposition pattern.

Dose Equivalent

The measure of potential biological damage caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose, dose is expressed as a millirem (mrem), or 1/1000 of a rem. In the International System of Units, 100 rem = 1 Sievert (Sv); 100 mrem = 1 millisievert (mSv).

DOSE

Many terms are used to report dose (Figure A.4). Several factors are taken into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose," in this report, includes the committed effective dose equivalent (EDE) and the EDE attributable to penetrating radiation from sources external to the body.

Determining dose is an involved process using complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet. Basically, radiant energy is generated from radioactive decay, or activity. People absorb some of the energy to which they are exposed. This absorbed energy is calculated as part of an individual's dose. Whether radiation is natural or human made, its effects on people are the same.

Comparison of Dose Levels

A comparison of some dose levels is presented in Table A.1. Included is an example of the type of exposure that may cause such a dose or the special significance of such a dose. This information is intended to help the reader become familiar with the type of doses individuals may receive.

Dose Terminology

absorbed dose	quantity of radiation energy absorbed by an organ divided by an organ's mass
dose equivalent	absorbed dose to an organ multiplied by a quality factor
effective dose equivalent	single weighted sum of combined dose equivalents received by all organs
committed dose equivalent	effective dose equivalent to an organ over a 50-year period following intake
committed effective dose equivalent	total effective dose equivalent to all organs in the human body over a 50-year period following intake
collective effective dose equivalent	sum of effective dose equivalents of all members of a given population
quality factor	a modifying factor used to adjust for the effect of the type of radiation, for example, alpha particles or gamma rays, on tissue
weighting factor	tissue-specific modifying factor representing the fraction of the total health risk from uniform, whole-body exposure

Figure A.4 Dose terminology.

Dose from Cosmic Radiation

The average annual dose received by residents of the United States from cosmic radiation is about 27 mrem (0.27 mSv) (NCRP 1987). The average annual dose from cosmic radiation received by residents in the Paducah area is about 45 mrem (0.45 mSv).

Table A.1 Comparison and description of various dose levels

Dose level	Description
1 mrem (0.01 mSv)	Approximate daily dose from natural background radiation, including radon.
2.5 mrem (0.025 mSv)	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles.
10 mrem (0.10 mSv)	Annual exposure limit, set by the EPA for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills.
45 mrem (0.45 mSv)	Average yearly dose from cosmic radiation received by people in the Paducah area.
46 mrem (0.46 mSv)	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear power plant accident.
66 mrem (0.66 mSv)	Average yearly dose to people in the United States from human-made sources.
100 mrem (1.00 mSv)	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker.
110 mrem (1.10 mSv)	Average occupational dose received by U.S. commercial radiation workers in 1980.
244 mrem (2.44 mSv)	Average dose from an upper gastrointestinal diagnostic X-ray series.
300 mrem (3.00 mSv)	Average yearly dose to people in the United States from all sources of natural background radiation.
1-5 rem (0.01-0.05 Sv)	EPA protective action guidelines state that public officials should take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range.
5 rem (0.05 Sv)	Annual limit for occupational exposure of radiation workers set by NRC and DOE.
10 rem (0. 10 Sv)	The BEIR V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer, caused by the radiation, of 0.8% (BEIR 1990).
25 rem (0.25 Sv)	EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency.
75 rem (0.75 Sv)	EPA guideline for maximum dose to emergency workers volunteering for lifesaving work.
50-600 rem (0.50-6.00 Sv)	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days.

Adapted from *Savannah River Site Environmental Report for 1993, Summary Pamphlet,* WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

Dose from Terrestrial Radiation

The average annual dose received from terrestrial gamma radiation is about 28 mrem (0.28 mSv) in the United States. This dose varies geographically across the country (NCRP 1987); typical reported values are 16 mrem (0.16 mSv) at the Atlantic and Gulf coastal plains and 63 mrem (0.63 mSv) at the eastern slopes of the Rocky Mountains. In the Paducah area, background levels of radionuclides in soils are within typical levels indicating that the dose received from terrestrial gamma radiation is within the range of typical reported values discussed previously (DOE 1997).

Dose from Internal Radiation

Short-lived decay products of radon are the major contributors to the annual dose equivalent for internal radionuclides (mostly ^{222}Rn). They contribute an average dose of about 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (NCRP 1987).

The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, most of which can be attributed to the naturally occurring isotope of potassium, ^{40}K. The concentration of radioactive potassium in human tissues is similar in all parts of the world. Table A.2 presents the internal dose factors for an adult.

Dose from Consumer Products

The United States average annual dose received by an individual from consumer products is about 10 mrem (0.10 mSv) (NCRP 1987).

Dose from Medical Sources

Nuclear medicine examinations, which involve the internal administration of radiopharmaceuticals, generally account for the largest portion of the dose received from human-made sources. However, the radionuclides used in specific tests are not distributed uniformly throughout the body. In these cases, comparisons are made using the concept of EDE, which relates exposure of organs or body parts to one effective whole-body dose. The average annual EDE from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X-rays and 14 mrem (0. 14 mSv) for nuclear medicine procedures (NCRP 1989). The actual doses received by individuals who complete such medical exams are much higher than these values, but not everyone receives such exams each year (NCRP 1989).

Dose from Other Sources

Small doses received by individuals occur as a result of radioactive fallout from atmospheric atomic weapons tests, emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 1987).

A comprehensive EPA report of 1984 projected the average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (EPA 1984).

Table A.2 Internal dose factors for an adult

Isotope	Half-life (years)	Intake[a] (mrem/pCi)			
		Inhalation (soluble)	Inhalation (slightly soluble)	Inhalation (insoluble)	Ingestion
^{234}U	240,000	0.0027	0.0071	0.13	0.00026
^{235}U	710,000,000	0.0025	0.0067	0.12	0.00025
^{238}U	4,500,000,000	0.0024	0.0062	0.12	0.00023
^{99}Tc	210,000	0.00000084	0.0000075	0.12	0.0000013
^{237}Np	2,100,000	NA	0.49	NA	0.0039
^{239}Pu	24,000	NA	0.51	0.33	0.0043
^{230}Th	75,000	NA	0.32	0.26	0.00053

[a] Source: U.S. DOE. July 1988. *Internal Dose Conversion Factors for Calculations of Dose to the Public*, DOE/EH-0071.

NA = not available in the above-referenced document

Table A.3 Annual dose estimates for 2000 of worst-case incidental ingestion of sediment from Bayou and Little Bayou creeks

Analysis	Average Concentration (pCi/g)	Average Concentration (pCi/g)	Ingestion Rate (mg/d)	Frequency (days)	Total Intake (pCi)	Ingestion Dose Conversion Factor (mrem/pCi)	CEDE (mrem)	Total Location Dose (mrem)
Downstream Bayou Creek (SS1)								
Neptunium-237	0.04	0.04	50	106	0.21	0.0039	0.0008	
Plutonium-239	0.02	0.02	50	106	0.11	0.0043	0.0005	
Technetium-99	0.6	0.6	50	106	3.18	0.00013	0.0004	
Thorium-230	0.17	0.17	50	106	0.90	0.00053	0.0005	
Uranium-234	1.7	1.7	50	106	9.01	0.00026	0.0023	
Uranium-235	0.09	0.09	50	106	0.48	0.00025	0.0001	
Uranium-238	2.74	2.74	50	106	14.52	0.00023	0.0033	0.0080
Downstream Bayou Creek (SS34)								
Neptunium-237	0.03	0.03	50	106	0.16	0.0039	0.0006	
Plutonium-239	0.05	0.05	50	106	0.27	0.0043	0.0011	
Technetium-99	0.89	0.89	50	106	4.72	0.00013	0.0006	
Thorium-230	1.56	1.56	50	106	8.27	0.00053	0.0044	
Uranium-234	0.67	0.67	50	106	3.55	0.00026	0.0009	
Uranium-235	0.04	0.04	50	106	0.21	0.00025	0.0001	
Uranium-238	1.67	1.67	50	106	8.85	0.00023	0.0020	0.0098
Downstream Little Bayou Creek (SS2)								
Neptunium-237	0	0	50	106	0.00	0.0039	0.0000	
Plutonium-239	0	0	50	106	0.00	0.0043	0.0000	
Technetium-99	0.1	0.1	50	106	0.53	0.00013	0.0001	
Thorium-230	0.15	0.15	50	106	0.80	0.00053	0.0004	
Uranium-234	0.21	0.21	50	106	1.11	0.00026	0.0003	
Uranium-235	0.02	0.02	50	106	0.11	0.00025	0.0000	
Uranium-238	1.14	1.14	50	106	6.04	0.00023	0.0014	0.0022
Downstream Little Bayou Creek (SS27)								
Neptunium-237	0.02	0.02	50	106	0.11	0.0039	0.0004	
Plutonium-239	0.13	0.13	50	106	0.69	0.0043	0.0030	
Technetium-99	12.49	12.49	50	106	66.20	0.00013	0.0086	
Thorium-230	2.1	2.1	50	106	11.13	0.00053	0.0059	
Uranium-234	0.97	0.97	50	106	5.14	0.00026	0.0013	
Uranium-235	0.07	0.07	50	106	0.37	0.00025	0.0001	
Uranium-238	2.92	2.92	50	106	15.48	0.00023	0.0036	0.0229
Downstream Little Bayou Creek (SS33)								
Neptunium-237	0.01	0.01	50	106	0.05	0.0039	0.0002	
Plutonium-239	0.02	0.02	50	106	0.11	0.0043	0.0005	
Technetium-99	0.35	0.35	50	106	1.86	0.00013	0.0002	
Thorium-230	0.18	0.18	50	106	0.95	0.00053	0.0005	
Uranium-234	0.62	0.62	50	106	3.29	0.00026	0.0009	
Uranium-235	0.04	0.04	50	106	0.21	0.00025	0.0001	
Uranium-238	1.06	1.06	50	106	5.62	0.00023	0.0013	0.0036
Upstream Bayou Creek (SS20)								
Neptunium-237	0	0	50	106	0.00	0.0039	0.0000	
Plutonium-239	0	0	50	106	0.00	0.0043	0.0000	
Technetium-99	0.11	0.11	50	106	0.58	0.00013	0.0001	
Thorium-230	0.08	0.08	50	106	0.42	0.00053	0.0002	
Uranium-234	0	NM	50	106	0.00	0.00026	0.0000	
Uranium-235	0	NM	50	106	0.00	0.00025	0.0000	
Uranium-238	0	NM	50	106	0.00	0.00023	0.0000	0.0003
Upstream Little Bayou Creek (SS21)								
Neptunium-237	0	0	50	106	0.00	0.0039	0.0000	
Plutonium-239	0	0	50	106	0.00	0.0043	0.0000	
Technetium-99	0.15	0.15	50	106	0.80	0.00013	0.0001	
Thorium-230	0.26	0.26	50	106	1.38	0.00053	0.0007	
Uranium-234	0	N M	50	106	0.00	0.00026	0.0000	
Uranium-235	0	NM	50	106	0.00	0.00025	0.0000	
Uranium-238	0	NM	50	106	0.00	0.00023	0.0000	0.0008
Reference Site Massac Creek (SS28)								
Neptunium-237	0.01	0.01	50	106	0.05	0.0039	0.0002	
Plutonium-239	0.01	0.01	50	106	0.05	0.0043	0.0002	
Technetium-99	0.06	0.06	50	106	0.32	0.00013	0.0000	
Thorium-230	0.11	0.11	50	106	0.58	0.00053	0.0003	
Uranium-234	0	NM	50	106	0.00	0.00026	0.0000	
Uranium-235	0	NM	50	106	0.00	0.00025	0.0000	
Uranium-238	0	NM	50	106	0.00	0.00023	0.0000	0.0008

NM = Not Measured
Calculation of CEDE above background location:
Big Bayou downstream(SS 34) - Big Bayou upstream(SS20) = 0.0094663 mrem
Bayou downstream (SS34)- Bayou upstream (SS20) = 0.0095 mrem
Little Bayou downstream(SS 33) - Little Bayou upstream(SS21) = 0.0013621 mrem
Little Bayou downstream (SS27) - Little Bayou upstream (SS21) = 0.022 mrem
Total calculated estimate of CEDE from sediment ingestion: 0.0095 + 0.022 = 0.032 mrem

Appendix B: Radionuclide and Chemical Nomenclature

Table B.1 Half-life and DCG for selected radionuclides

Radionuclide	Symbol	Half-life	Ingested Water DCG (µCi/ml)
Americium-241	^{241}Am	432 years	3 E - 08
Bismuth-210	^{210}Bi	5.01 days	2 E - 05
Cesium-137	^{137}Cs	30.2 years	3 E - 06
Cobalt-60	^{60}Co	5.3 years	1 E - 05
Lead-206	^{206}Pb	Stable	None
Lead-210	^{210}Pb	21 years	3 E - 08
Lead-214	^{214}Pb	26.8 minutes	2 E - 04
Neptunium-237	^{237}Np	2,140,000 years	3 E - 08
Plutonium-239	^{239}Pu	24,110 years	3 E - 08
Polonium-210	^{210}Po	138.9 days	8 E - 08
Polonium-214	^{214}Po	164 microseconds	None
Polonium-218	^{218}Po	3.05 minutes	None
Potassium-40	^{40}K	1,260,000,000 years	7 E - 06
Protactinium-234m	^{234m}Pa	1. 17 minutes	None
Radium-226	^{226}Ra	1,602 years	1 E - 07
Radon-222	^{222}Rn	3.821 days	None
Technetium-99	^{99}Tc	212,000 years	1 E - 04
Thorium-230	^{230}Th	80,000 years	3 E - 07
Thorium-231	^{231}Th	25.5 hours	1 E - 04
Thorium-234	^{234}Th	24.1 days	1 E - 05
Uranium-234	^{234}U	247,000 years	5 E - 07
Uranium-235	^{235}U	710,000,000 years	6 E - 07
Uranium-236	^{236}U	23,900,000 years	5 E - 07
Uranium-238	^{238}U	4,510,000,000 years	6 E - 07

Derived Concentration Guide (DCG) is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 mrem. DCGs do not consider decay products when the parent radionuclide is the cause of the exposure.

Table B.2 Nomenclature for elements and chemical compounds

Constituent	Symbol	Constituent	Symbol
Aluminum	Al	Manganese	Mn
Ammonia	NH_3	Mercury	Hg
Antimony	Sb	Nickel	Ni
Arsenic	As	Nitrate	NO_3
Barium	Ba	Nitrite	NO_2
Beryllium	Be	Nitrogen	N
Cadmium	Cd	Oxygen	O
Calcium	Ca	Ozone	O_3
Calcium carbonate	$CaCO_3$	Phosphate	PO_4
Carbon	C	Phosphorus	P
Chlorine	Cl	Potassium	K
Chromium	Cr	Radium	Ra
Chromium, hexavalent	Cr^{6+}	Radon	Rn
Cobalt	Co	Selenium	Se
Copper	Cu	Silver	Ag
Fluorine	F	Sodium	Na
Hydrogen fluoride	HF	Sulfate	SO_4
Iron	Fe	Sulfur dioxide	SO_2
Lead	Pb	Thorium	Th
Lithium	Li	Uranium	U
Magnesium	Mg	Zinc	Zn

Appendix C: Data Tables

Notes:

1. Selected results are discussed in the appropriate sections of the text of this report.

2. "ND" means the parameter was not detected. Detection limits are available in the Paducah OREIS database.

3. Monitoring programs often include measurement of extremely low concentrations of radionuclides, below the detection limit of the counting instruments. Less-than-detectable data will produce numerical measurements with values below the detection limit and sometimes negative values. All of the actual values, including those that are negative, are included in the statistical analyses in accordance with DOE's *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991).

4. Average values are calculated using the actual result values from the OREIS database. Where analyitical result values were below the detection level, half of the detection limit was used to calculate average concentration.

Appendix C Listing of Tables

Appendix C Listing of Tables (Cont.)

Appendix C Listing of Tables (Cont.)

KPDES Radiological Data

Table C.1 Radiological Effluent Data for Outfall 001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Dissolved Alpha	pCi/L	0.94	33.1	14.3	2	5	6.47	6.5
Dissolved Beta	pCi/L	16.3	107	60.5	5	5	11.2	20.1
Suspended Alpha	pCi/L	-0.11	2.25	1.11	0	5	4.68	5.81
Suspended Beta	pCi/L	-4.19	16.6	5.98	2	5	8.21	9.86
Technetium-99	pCi/L	-5.64	96.9	38.3	3	6	16.1	18.0
Tritium	pCi/L	-151	209	-37.8	0	8	300	300

Table C.2 Radiological Effluent Data for Outfall 015

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Dissolved Alpha	pCi/L	5.96	118	39.1	3	4	5.27	6.49
Dissolved Beta	pCi/L	20.9	134	67.2	4	4	9.27	14.4
Suspended Alpha	pCi/L	1.15	3.09	2.05	0	4	4.46	6.01
Suspended Beta	pCi/L	2.03	39.9	13.6	2	4	7.81	9.39
Technetium-99	pCi/L	14.5	58.1	37.0	3	4	17.1	23.2
Tritium	pCi/L	-236	162	11.5	0	8	300	300

Table C.3 Radiological Effluent Data for Outfall 017

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Dissolved Alpha	pCi/L	-2.4	1.95	-0.212	0	5	5.07	8.82
Dissolved Beta	pCi/L	4.22	40.6	20.2	3	5	12.6	12.8
Suspended Alpha	pCi/L	-0.41	2.18	0.648	0	5	4.36	5.88
Suspended Beta	pCi/L	-8.63	2.92	-2.06	0	5	7.63	9.39
Technetium-99	pCi/L	-11.9	10.9	2.89	0	5	16.2	23.2
Tritium	pCi/L	-83.4	239	50.0	0	7	300	300

KPDES Radiological Data

Table C.4 Radiological Effluent Data for Outfall 019

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Dissolved Alpha	pCi/L	-0.39	1.27	0.497	0	3	3.64	4.78
Dissolved Beta	pCi/L	4.54	5.51	5.02	0	3	7.56	8.40
Suspended Alpha	pCi/L	-0.7	0.605	-0.055	0	3	2.44	4.39
Suspended Beta	pCi/L	1.5	2.95	0.021	0	3	7.14	7.69
Technetium-99	pCi/L	-2.55	-2.55	-2.55	0	1	17.9	17.9
Tritium	pCi/L	-184	-0.79	-92.4	0	2	300	300

Surface Water Radiological Data

Table C.5 Radiological Effluent Data for Surface Water Location L1

Upstream Bayou Creek (Background)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-20.1	10.8	-4.65	0	4	42.4	76
Cesium-134	pCi/L	-7.42	0.295	-2.23	0	4	13.1	18.2
Cesium-137	pCi/L	-5.52	18.8	4.90	1	4	16.9	20.7
Cobalt-60	pCi/L	-0.158	10.5	5.47	0	4	19.8	26.5
Dissolved Alpha	pCi/L	-2.23	2.12	-0.636	0	5	7.22	9.55
Dissolved Beta	pCi/L	3.11	15.2	8.72	2	5	10.5	13.7
Gamma Activity	pCi/L	8540	8540	8540	1	1	29.7	29.7
Neptunium-237	pCi/L	-0.108	0.586	0.206	0	5	0.751	0.949
Plutonium-238	pCi/L	-0.221	0.0247	-0.0607	0	4	0.301	0.853
Plutonium-239	pCi/L	-0.0406	0.0355	-0.00782	0	5	0.134	0.257
Potassium-40	pCi/L	-93.2	-5.5	-56.8	0	4	339	514
Suspended Alpha	pCi/L	-1.34	0.718	-0.362	0	5	4.58	5.73
Suspended Beta	pCi/L	-1.97	3.61	0.582	0	5	7.46	8.91
Technetium-99	pCi/L	-11.5	8.61	-0.59	0	5	15.7	21.8
Thorium-228	pCi/L	-0.0543	0.0601	0.0018	0	4	0.216	0.556
Thorium-230	pCi/L	-0.121	0.0774	-0.0144	0	5	0.245	0.519
Thorium-232	pCi/L	-0.0034	0.0467	0.0161	0	4	0.144	0.228
Uranium-235	pCi/L	0	0	0	0	4	0.922	1.06

Table C.6 Radiological Effluent Data for Surface Water Location L5

Downstream Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-5.1	11.6	2.13	0	3	34.9	75.7
Cesium-134	pCi/L	-15.3	-2.55	-7.54	0	3	15.2	16
Cesium-137	pCi/L	-5.22	6.28	1.87	0	3	15.5	21.5
Cobalt-60	pCi/L	4.25	10.8	7.46	0	3	17.9	26.4
Dissolved Alpha	pCi/L	-1.51	20.2	6.48	1	4	11.6	11.6
Dissolved Beta	pCi/L	3.41	38.3	16.9	3	4	12.8	15.4
Gamma Activity	pCi/L	8900	8900	8900	1	1	24.3	24.3
Neptunium-237	pCi/L	-0.1	0.13	-0.0334	0	4	0.751	0.949
Plutonium-238	pCi/L	-0.227	0.002	-0.097	0	3	0.302	0.85
Plutonium-239	pCi/L	-0.038	1.26	0.303	1	4	0.143	0.258
Potassium-40	pCi/L	-135	287	54.0	1	3	227	359
Suspended Alpha	pCi/L	-2.45	1.14	-0.306	0	4	4.48	5.63
Suspended Beta	pCi/L	-3.73	3.99	0.378	0	4	7.43	9.33
Technetium-99	pCi/L	2.34	25.2	9.8	1	4	15.5	21.8
Thorium-228	pCi/L	-0.0543	0.0088	-0.025	0	3	0.234	0.552
Thorium-230	pCi/L	-0.0757	1.86	0.457	1	4	0.257	0.523
Thorium-232	pCi/L	-0.0124	0.0161	0.0045	0	3	0.153	0.272
Uranium-235	pCi/L	0	17.8	5.93	0	3	0.937	19.5

Surface Water Radiological Data

Table C.7 Radiological Effluent Data for Surface Water Location L6

Downstream of Plant Effluents in Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-7.73	29.5	9.09	0	3	46.4	98.7
Cesium-134	pCi/L	-18.2	4.94	-3.59	0	3	15.8	23.7
Cesium-137	pCi/L	-4.9	4.68	0.623	0	3	17.6	22.7
Cobalt-60	pCi/L	2.41	4.74	3.83	0	3	18.7	27.7
Dissolved Alpha	pCi/L	0.55	14.8	5.52	1	3	11.7	7.98
Dissolved Beta	pCi/L	11.0	24.6	19.7	2	3	11.6	14.1
Neptunium-237	pCi/L	-0.1	0.578	0.243	0	3	0.751	0.949
Plutonium-238	pCi/L	-0.0535	-0.0142	-0.0028	0	3	0.302	0.85
Plutonium-239	pCi/L	-0.0436	0.0459	-0.0137	0	3	0.133	0.168
Potassium-40	pCi/L	-78.1	174	20.0	0	3	14.4	510
Suspended Alpha	pCi/L	-0.9	3.15	0.623	0	3	4.44	5.81
Suspended Beta	pCi/L	-2.38	4.83	1.47	0	3	7.42	8.95
Technetium-99	pCi/L	8.98	13.1	11.0	0	3	15.7	21.8
Thorium-228	pCi/L	-0.0667	0.0234	-0.0361	0	3	0.235	0.564
Thorium-230	pCi/L	-0.0568	0.0292	-0.0039	0	3	0.255	0.542
Thorium-232	pCi/L	-0.0156	0.0108	0.0005	0	3	0.152	0.297
Uranium-235	pCi/L	0	0	0	0	3	0.941	1.51

Table C.8 Radiological Effluent Data for Surface Water Location L8

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-14	12	0.19	0	3	44.6	96.1
Cesium-134	pCi/L	-13	-0.117	-4.42	0	3	17.2	22.3
Cesium-137	pCi/L	-4.05	-0.385	-2.66	0	3	18	24.5
Cobalt-60	pCi/L	0.834	4.81	2.88	0	3	20.1	21.9
Dissolved Alpha	pCi/L	0.12	1.88	1.02	0	3	7.38	9.97
Dissolved Beta	pCi/L	5.1	19.6	10.2	1	3	11.7	13.1
Neptunium-237	pCi/L	-0.08	1.51	0.494	1	3	0.751	0.949
Plutonium-238	pCi/L	-0.138	-0.0338	-0.0767	0	3	0.31	0.851
Plutonium-239	pCi/L	-0.0666	-0.0352	-0.046	0	3	0.135	0.167
Potassium-40	pCi/L	-155	-25	-78.3	0	3	375	514
Suspended Alpha	pCi/L	0.17	2.8	1.36	0	3	4.85	6.47
Suspended Beta	pCi/L	-5.28	12.1	1.80	1	3	7.53	9.45
Technetium-99	pCi/L	-3.29	24.4	10.2	1	4	15.7	21.8
Thorium-228	pCi/L	-0.0543	0.0083	-0.0141	0	3	0.21	0.551
Thorium-230	pCi/L	-0.133	-0.0361	-0.0731	0	3	0.255	0.536
Thorium-232	pCi/L	-0.0125	0.0357	0.0127	0	3	0.15	0.293
Uranium-235	pCi/L	0	0	0	0	3	0.946	1.53

Surface Water Radiological Data

Table C.9 Radiological Effluent Data for Surface Water Location L10

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-1.94	3.68	1.28	0	3	46.8	74.7
Cesium-134	pCi/L	-13.1	4.01	-3.42	0	3	13.9	18.4
Cesium-137	pCi/L	-8.65	3.05	-4.56	0	3	16.1	19.9
Cobalt-60	pCi/L	-3.48	-2.17	-2.87	0	3	15.1	28.4
Dissolved Alpha	pCi/L	-0.49	11.3	3.43	1	5	6.44	6.44
Dissolved Beta	pCi/L	0.21	13.7	8.42	1	5	11.6	14.1
Gamma Activity	pCi/L	15200	15300	15200	2	2	40.7	44.2
Neptunium-237	pCi/L	-0.179	0.93	0.222	1	5	0.751	0.949
Plutonium-238	pCi/L	-0.151	-0.0514	-0.091	0	3	0.302	0.855
Plutonium-239	pCi/L	-0.0409	0.0224	-0.0053	0	5	0.137	0.259
Potassium-40	pCi/L	21	634	270	2	3	172	551
Suspended Alpha	pCi/L	-1.21	0.68	0.017	0	5	4.35	4.98
Suspended Beta	pCi/L	-1.36	1.85	0.092	0	5	7.39	9.18
Technetium-99	pCi/L	-4.33	47.4	7.76	1	5	15.7	21.8
Thorium-228	pCi/L	-0.0635	0.0125	-0.0202	0	3	0.235	0.552
Thorium-230	pCi/L	-0.0841	0.0902	0.0049	0	5	0.256	0.497
Thorium-232	pCi/L	-0.0191	0.0239	0.0043	0	3	0.155	0.219
Uranium-235	pCi/L	0	0	0	0	3	0.924	1.06

Table C.10 Radiological Effluent Data for Surface Water Location L11

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-14.4	32.7	8.17	0	3	48.5	78.2
Cesium-134	pCi/L	-12.7	-3.26	-6.48	0	3	14.8	16.7
Cesium-137	pCi/L	-5.23	12.7	1.12	0	3	16	19.8
Cobalt-60	pCi/L	-9.75	9.22	-0.461	0	3	16.8	21.1
Dissolved Alpha	pCi/L	0.04	9.89	4.39	1	4	7.15	8.17
Dissolved Beta	pCi/L	8.84	18.9	11.9	2	4	10.8	13.9
Gamma Activity	pCi/L	15100	15100	15100	1	1	36.9	36.9
Neptunium-237	pCi/L	-0.108	0.78	0.488	1	4	0.751	1.52
Plutonium-238	pCi/L	-0.0678	0.0702	-0.0038	0	3	0.302	0.852
Plutonium-239	pCi/L	-0.03	0.0175	-0.0115	0	4	0.136	0.26
Potassium-40	pCi/L	-126	-54.2	-79.7	0	3	338	492
Suspended Alpha	pCi/L	-0.86	2	0.698	0	4	4.51	6.16
Suspended Beta	pCi/L	2	4.14	3.11	0	4	7.44	9.04
Technetium-99	pCi/L	-11.3	17.3	-0.035	1	4	15.5	21.8
Thorium-228	pCi/L	-0.0157	0.0315	0.0014	0	3	0.197	0.661
Thorium-230	pCi/L	-0.0728	0.0297	-0.0147	0	4	0.252	0.493
Thorium-232	pCi/L	-0.0413	0.0082	-0.0115	0	3	0.155	0.357
Uranium-235	pCi/L	0	0	0	0	3	0.932	1.06

Surface Water Radiological Data

Table C.11 Radiological Effluent Data for Surface Water Location L12

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-61.8	38.3	-7.39	0	3	43.7	131
Cesium-134	pCi/L	-1.32	12.9	4.43	0	3	15.3	24.9
Cesium-137	pCi/L	-0.627	5.97	3.01	0	3	18.3	31
Cobalt-60	pCi/L	-9.1	-2.15	-5.22	0	3	15.6	29.2
Dissolved Alpha	pCi/L	1.74	2.53	2.15	0	3	6.98	8.14
Dissolved Beta	pCi/L	9.83	15.6	12.9	2	3	13.7	13.7
Neptunium-237	pCi/L	-0.251	0.79	0.1	1	3	0.751	0.949
Plutonium-238	pCi/L	-0.14	0.114	-0.043	0	3	0.305	0.849
Plutonium-239	pCi/L	-0.0334	-0.0005	-0.022	0	3	0.137	0.165
Potassium-40	pCi/L	-203	-51.1	-128	0	3	343	500
Suspended Alpha	pCi/L	-1.35	3.78	1.03	0	3	4.71	9.67
Suspended Beta	pCi/L	-0.14	34.5	11.60	1	3	13.9	9.46
Technetium-99	pCi/L	13.3	32.2	21.4	2	4	15.7	21.8
Thorium-228	pCi/L	-0.0196	0.0442	0.0082	0	3	0.215	0.505
Thorium-230	pCi/L	-0.0626	0.00756	-0.0354	0	3	0.248	0.524
Thorium-232	pCi/L	-0.034	0.0206	-0.0028	0	3	0.152	0.261
Uranium	pCi/L	8830	8830	8830	1	1	1490	1490
Uranium-234	pCi/L	3600	3600	3600	1	1	607	607
Uranium-235	pCi/L	-7.42	192	61.5	1	3	0.943	607
Uranium-238	pCi/L	5300	5300	5300	1	1	850	850

Table C.12 Radiological Effluent Data for Surface Water Location L29

Upstream Ohio River (Reference)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-12.9	6.12	-2.45	0	3	45.6	88.4
Cesium-134	pCi/L	-13.6	3.77	-6.63	0	3	18	21
Cesium-137	pCi/L	-5.49	1.45	-1.194	0	3	18.1	27.6
Cobalt-60	pCi/L	-1.64	0.662	-0.590	0	3	15.2	24.6
Dissolved Alpha	pCi/L	1.43	2.08	1.68	0	4	6.4	9.62
Dissolved Beta	pCi/L	-0.18	32.1	10.9	1	4	10.8	11.9
Gamma Activity	pCi/L	8820	8820	8820	1	1	25.7	25.7
Neptunium-237	pCi/L	-0.466	0.599	0.143	0	4	0.751	0.949
Plutonium-238	pCi/L	-0.184	0.0833	-0.0482	0	3	0.302	0.85
Plutonium-239	pCi/L	-0.0432	0.0004	-0.0254	0	4	0.135	0.249
Potassium-40	pCi/L	-160	540	163	1	3	220	427
Suspended Alpha	pCi/L	-0.38	2.41	0.825	0	4	4.37	6.04
Suspended Beta	pCi/L	-1.1	7.57	2.33	0	4	7.39	9.33
Technetium-99	pCi/L	-4.41	11.8	1.92	0	4	15.5	21.8
Thorium-228	pCi/L	-0.0543	0.0099	-0.017	0	3	0.205	0.558
Thorium-230	pCi/L	-0.14	-0.0102	-0.0685	0	4	0.261	0.502
Thorium-232	pCi/L	0.0069	0.0092	0.0080	0	3	0.154	0.264
Uranium-235	pCi/L	0	0	0	0	3	0.936	1.21

Surface Water Radiological Data

Table C.13 Radiological Effluent Data for Surface Water Location L30

Downstream Ohio River

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-54.2	18.3	-8.6	0	3	34.9	78.7
Cesium-134	pCi/L	-2.1	-1.54	-1.89	0	3	15.1	18.9
Cesium-137	pCi/L	2.36	6.52	4.43	0	3	16.2	20.6
Cobalt-60	pCi/L	-1.52	4.42	2.05	0	3	18.7	24.8
Dissolved Alpha	pCi/L	-0.55	2.15	0.757	0	4	6.63	9.62
Dissolved Beta	pCi/L	-5.42	6.37	2.79	0	4	8.34	12.2
Gamma Activity	pCi/L	15500	15500	15500	1	1	50.1	50.1
Neptunium-237	pCi/L	-0.23	1.3	0.232	1	4	0.751	0.949
Plutonium-238	pCi/L	-0.203	-0.034	-0.101	0	3	0.301	0.851
Plutonium-239	pCi/L	-0.036	0.016	-0.008	0	4	0.139	0.248
Potassium-40	pCi/L	-317	-3.67	-142	0	3	346	444
Suspended Alpha	pCi/L	-0.682	2.99	0.789	0	4	4.77	6.72
Suspended Beta	pCi/L	-2.72	3.03	0.882	0	4	7.51	11.1
Technetium-99	pCi/L	1.84	4.37	3.07	0	4	15.5	21.8
Thorium-228	pCi/L	-0.0543	0.0387	-0.0024	0	3	0.213	0.56
Thorium-230	pCi/L	-0.0985	0.0733	-0.0271	0	4	0.255	0.503
Thorium-232	pCi/L	0.000	0.045	0.020	0	3	0.161	0.256
Uranium-235	pCi/L	0	0	0	0	3	0.94	1.06

Table C.14 Radiological Effluent Data for Surface Water Location L55

Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-14.1	-6.05	-9.73	0	4	45.3	73.9
Cesium-134	pCi/L	0.771	14.2	5.23	0	4	16.6	22.4
Cesium-137	pCi/L	-10.7	1.94	-2.09	0	4	17.5	20.2
Cobalt-60	pCi/L	-1.13	2.66	0.147	0	4	17.6	25.5
Dissolved Alpha	pCi/L	0.47	15.3	7.18	1	4	7.68	9.65
Dissolved Beta	pCi/L	-2.01	12.7	6.72	1	4	8.34	8.47
Neptunium-237	pCi/L	-0.287	0.49	-0.018	0	4	0.751	0.949
Plutonium-238	pCi/L	-0.158	0.0146	-0.0732	0	4	0.3	0.854
Plutonium-239	pCi/L	-0.0474	-0.0069	-0.0256	0	4	0.133	0.168
Potassium-40	pCi/L	-191	112	-24.3	0	4	360	563
Suspended Alpha	pCi/L	-1.16	3.9	0.384	0	4	4.33	5.16
Suspended Beta	pCi/L	-3.22	4.16	1.05	0	4	7.38	9.46
Technetium-99	pCi/L	-9.37	7.42	0.216	0	4	15.7	21.8
Thorium-228	pCi/L	-0.0212	0.0516	0.0234	0	4	0.223	0.559
Thorium-230	pCi/L	-0.0803	0.0777	0.0099	0	4	0.248	0.557
Thorium-232	pCi/L	-0.0016	0.0291	0.0167	0	4	0.151	0.271
Uranium-235	pCi/L	-6.16	0	-4.27	0	4	0.924	1.07

Surface Water Radiological Data

Table C.15 Radiological Effluent Data for Surface Water Location L56

Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-23.1	17.6	-4.86	0	3	47.5	72.8
Cesium-134	pCi/L	1.34	5.95	4.35	0	3	16.2	18.5
Cesium-137	pCi/L	-3.4	-0.354	-1.95	0	3	17.6	22.5
Cobalt-60	pCi/L	2.72	13.2	8.71	0	3	18	26.4
Dissolved Alpha	pCi/L	-0.627	3.38	0.921	0	3	6.44	10.4
Dissolved Beta	pCi/L	-0.22	10.1	6.26	1	3	11.6	8.47
Neptunium-237	pCi/L	0	0.576	0.202	0	3	0.751	0.949
Plutonium-238	pCi/L	-0.0429	0.0811	0.033	0	3	0.31	0.854
Plutonium-239	pCi/L	-0.0383	-0.0165	-0.029	0	3	0.137	0.169
Potassium-40	pCi/L	-268	195	-11.3	0	3	140	538
Suspended Alpha	pCi/L	0.071	3.07	1.40	0	3	4.68	4.82
Suspended Beta	pCi/L	-1.98	5.73	1.29	0	3	7.49	8.95
Technetium-99	pCi/L	-9.72	40.4	11.7	1	3	15.7	21.8
Thorium-228	pCi/L	-0.0406	0.0771	0.029	0	3	0.276	0.563
Thorium-230	pCi/L	-0.158	0.003	-0.101	0	3	0.249	0.53
Thorium-232	pCi/L	0.0101	0.241	0.093	0	3	0.15	0.305
Uranium-235	pCi/L	-13.9	-9.21	-10.8	0	3	0.92	1.07

Table C.16 Radiological Effluent Data for Surface Water Location L64

Massac Creek (Reference)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-18	4.28	-6.01	0	4	34.7	45.6
Cesium-134	pCi/L	-9.72	2.49	-4.49	0	4	13.8	17.1
Cesium-137	pCi/L	-7.52	8.36	0.066	0	4	17.4	23.2
Cobalt-60	pCi/L	-4.68	0.786	-2.01	0	4	17.9	26.4
Dissolved Alpha	pCi/L	-1.76	2.47	0.310	0	5	6.07	7.03
Dissolved Beta	pCi/L	-1.03	9.1	3.52	0	5	7.92	12.1
Gamma Activity	pCi/L	6770	6770	6770	1	1	21.3	21.3
Neptunium-237	pCi/L	-0.358	0.84	0.274	0	5	0.751	0.949
Plutonium-238	pCi/L	-0.099	0.107	-0.0200	0	4	0.3	0.853
Plutonium-239	pCi/L	-0.041	0.036	-0.001	0	5	0.135	0.258
Potassium-40	pCi/L	-402	-20.1	-139	0	4	316	508
Suspended Alpha	pCi/L	-1.07	2.15	0.3	0	5	4.48	5.55
Suspended Beta	pCi/L	-1.76	3.14	0.142	0	5	7.43	9.18
Technetium-99	pCi/L	-9.55	6.72	-2.630	0	5	15.7	21.8
Thorium-228	pCi/L	-0.066	0.029	-0.005	0	4	0.203	0.6
Thorium-230	pCi/L	-0.130	0.0166	-0.0457	0	5	0.245	0.518
Thorium-232	pCi/L	-0.0445	-0.0076	-0.0214	0	4	0.147	0.242
Uranium-235	pCi/L	-4.46	0.00	-1.12	0	4	0.935	1.07

Surface Water Radiological Data

Table C.17 Radiological Effluent Data for Surface Water Location L135

Upstream C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	2.88	12.5	6.74	4	4	2.34	5.56
Beta activity	pCi/L	19.5	46.2	32.5	4	4	4.19	6.46

Table C.18 Radiological Effluent Data for Surface Water Location L136

At the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	-2.48	1.4	0.28	0	4	2.82	8.55
Beta activity	pCi/L	11.4	14.8	13.0	4	4	4.59	7.01

Table C.19 Radiological Effluent Data for Surface Water Location L137

Downstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	0.99	9.01	4.46	2	4	2.3	6.46
Beta activity	pCi/L	13.4	77.6	34.0	4	4	4.3	5.3

Table C.20 Radiological Effluent Data for Surface Water Location L150

At the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	0.06	1.04	0.387	0	4	2.53	8.27
Beta activity	pCi/L	6.82	15.8	12.0	4	4	4.55	6.26

Surface Water Radiological Data

Table C.21 Radiological Effluent Data for Surface Water Location L154

Upstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	0.92	5.54	2.98	1	4	2.32	5.84
Beta activity	pCi/L	15.4	57.6	27.9	4	4	4.22	6.48

Table C.22 Radiological Effluent Data for Surface Water Location L155

Downstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/L	1.31	8.23	5.21	3	4	2.4	6.53
Beta activity	pCi/L	10.0	17	13.5	4	4	4.31	6.43

Table C.23 Radiological Effluent Data for Surface Water Location L194

Little Bayou Creek Downstream of Outfall K010

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-3.84	13.8	2.72	0	3	44	76.1
Cesium-134	pCi/L	-8.66	4.21	-1.48	0	3	13.7	18.7
Cesium-137	pCi/L	-5.03	4.15	-1.55	0	3	17.7	20.8
Cobalt-60	pCi/L	-2.25	3.85	1.55	0	3	16	24.8
Dissolved Alpha	pCi/L	3.37	16.9	9.00	2	3	6.65	7.45
Dissolved Beta	pCi/L	3.53	17.2	11.5	2	3	13.3	13.3
Neptunium-237	pCi/L	-0.108	0.35	0.136	0	3	0.751	0.949
Plutonium-238	pCi/L	-0.0794	0.0562	-0.0315	0	3	0.301	0.852
Plutonium-239	pCi/L	-0.025	-0.015	-0.021	0	3	0.136	0.164
Potassium-40	pCi/L	-133	49.5	-32.4	0	3	364	524
Suspended Alpha	pCi/L	-1.14	1.38	0.513	0	3	4.46	5.12
Suspended Beta	pCi/L	-3.53	6.85	0.273	0	3	7.42	9.39
Technetium-99	pCi/L	-1.16	14.9	5.84	0	3	15.7	21.8
Thorium-228	pCi/L	-0.064	0.017	-0.035	0	3	0.218	0.555
Thorium-230	pCi/L	-0.044	0.000	-0.025	0	3	0.253	0.509
Thorium-232	pCi/L	-0.0223	0.0069	-0.0087	0	3	0.16	0.231
Uranium-235	pCi/L	0	0	0	0	3	0.922	1.06

Surface Water Radiological Data

Table C.24 Radiological Effluent Data for Surface Water Location L241

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-22	13.3	-8.17	0	3	46.8	88.3
Cesium-134	pCi/L	-10.4	11	-0.893	0	3	16.1	23
Cesium-137	pCi/L	-0.924	6.34	3.60	0	3	17.2	25.5
Cobalt-60	pCi/L	2.69	5.61	4.43	0	3	16.5	29.6
Dissolved Alpha	pCi/L	3.08	7.01	4.59	0	3	6.82	7.75
Dissolved Beta	pCi/L	11.7	14.1	12.7	2	3	13.1	9.94
Neptunium-237	pCi/L	-0.323	0.38	0.026	0	3	0.751	0.949
Plutonium-238	pCi/L	-0.125	0.0694	-0.0308	0	3	0.304	0.851
Plutonium-239	pCi/L	-0.0088	0.0304	0.0079	0	3	0.138	0.169
Potassium-40	pCi/L	-0.352	598	201	1	3	226	399
Suspended Alpha	pCi/L	-0.19	1.59	0.770	0	3	4.61	6.48
Suspended Beta	pCi/L	1.97	5.01	2.99	0	3	7.47	9.47
Technetium-99	pCi/L	9.17	37.3	25.0	3	4	15.7	21.8
Thorium-228	pCi/L	-0.04	0.0215	-0.0016	0	3	0.21	0.565
Thorium-230	pCi/L	-0.096	0.098	-0.017	0	3	0.258	0.53
Thorium-232	pCi/L	-0.0034	0.0395	0.019	0	3	0.152	0.277
Uranium-235	pCi/L	-7.13	0	-2.38	0	3	0.936	1.21

Table C.25 Radiological Effluent Data for Surface Water Location L291

Upstream of Plant Effluents Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-6.58	5.35	0.7	0	3	36.2	48.1
Cesium-134	pCi/L	-7.4	1.49	-3.59	0	3	12.6	16.9
Cesium-137	pCi/L	-5.25	3.91	-1.06	0	3	14	20.7
Cobalt-60	pCi/L	-9.36	5.12	-1.17	0	3	13.1	25.2
Dissolved Alpha	pCi/L	-2.05	1.37	0.223	0	3	7.65	9.26
Dissolved Beta	pCi/L	8.25	12.0	9.89	2	3	13.6	13.6
Neptunium-237	pCi/L	-0.12	1.29	0.487	1	3	0.751	0.949
Plutonium-238	pCi/L	-0.123	-0.044	-0.094	0	3	0.304	0.85
Plutonium-239	pCi/L	-0.0723	-0.0072	-0.0291	0	3	0.141	0.165
Potassium-40	pCi/L	-321	-69.1	-155	0	3	306	497
Suspended Alpha	pCi/L	0.264	1.1	0.708	0	3	4.74	5.63
Suspended Beta	pCi/L	-1.85	1.98	-0.097	0	3	7.5	9.36
Technetium-99	pCi/L	-3.51	15.2	5.04	0	3	15.7	21.8
Thorium-228	pCi/L	-0.0543	0.00	-0.0217	0	3	0.251	0.577
Thorium-230	pCi/L	-0.0306	0.0218	0.0001	0	3	0.254	0.604
Thorium-232	pCi/L	0.0063	0.0479	0.0226	0	3	0.156	0.382
Uranium-235	pCi/L	-5.22	0.00	-3.25	0	3	0.937	1.07

Surface Water Radiological Data

Table C.26 Radiological Effluent Data for Surface Water Location L306

Cairo Intake Ohio River

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	4.23	7.98	5.90	0	3	38.3	74.8
Cesium-134	pCi/L	-11.8	-0.199	-4.74	0	3	14.7	17.2
Cesium-137	pCi/L	-0.971	0.593	0.000	0	3	15.5	22.1
Cobalt-60	pCi/L	-0.044	7.77	3.76	0	3	19.8	20.8
Dissolved Alpha	pCi/L	-1.98	-0.2	-1.12	0	4	6.38	9.72
Dissolved Beta	pCi/L	3.53	11.4	7.71	1	4	10.6	13.3
Gamma Activity	pCi/L	8900	8900	8900	1	1	28.6	28.6
Neptunium-237	pCi/L	-0.394	0.500	0.124	0	4	0.751	0.949
Plutonium-238	pCi/L	-0.201	0.000736	-0.087	0	3	0.306	0.85
Plutonium-239	pCi/L	-0.0277	0.00125	-0.0172	0	4	0.136	0.25
Potassium-40	pCi/L	-204	-83.0	-157	0	3	299	498
Suspended Alpha	pCi/L	-0.546	1.73	0.709	0	4	4.42	5.86
Suspended Beta	pCi/L	-2.35	4.07	1.4675	0	4	7.41	9.29
Technetium-99	pCi/L	-5.58	5.29	-0.89	0	4	15.5	21.8
Thorium-228	pCi/L	-0.0543	0.0087	-0.022	0	3	0.215	0.553
Thorium-230	pCi/L	-0.129	0.0006	-0.0605	0	4	0.253	0.516
Thorium-232	pCi/L	-0.0237	-0.0083	-0.0170	0	3	0.161	0.267
Uranium-235	pCi/L	0.00	0.00	0.00	0	3	0.943	1.09

Table C.27 Radiological Effluent Data for Surface Water Location C746K-5

Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/L	-5.71	19.8	4.50	0	3	48.1	104
Cesium-134	pCi/L	-2.5	6.28	0.763	0	3	15.8	21.1
Cesium-137	pCi/L	-8.41	3.02	-3.18	0	3	18	23.9
Cobalt-60	pCi/L	-5.7	2.44	-2.76	0	3	22.5	23.1
Dissolved Alpha	pCi/L	-1.5	3.00	0.977	0	3	7.23	8.33
Dissolved Beta	pCi/L	3.85	6.44	5.29	0	3	8.13	13.0
Neptunium-237	pCi/L	-0.287	0.200	0.020	0	3	0.751	0.949
Plutonium-238	pCi/L	-0.189	0.00493	-0.064	0	3	0.305	0.849
Plutonium-239	pCi/L	-0.0605	-0.00233	-0.0256	0	3	0.134	0.165
Potassium-40	pCi/L	-35.3	40.8	-1.93	0	3	470	539
Suspended Alpha	pCi/L	-1.97	-0.77	-1.24	0	3	4.56	5.59
Suspended Beta	pCi/L	-3.9	2.12	-0.266	0	3	7.45	9.43
Technetium-99	pCi/L	-4.74	-0.057	-1.63	0	3	15.7	21.8
Thorium-228	pCi/L	-0.0636	-0.016	-0.038	0	3	0.237	0.551
Thorium-230	pCi/L	-0.0635	0.228	0.052	0	3	0.25	0.651
Thorium-232	pCi/L	-0.0175	0.0836	0.021	0	3	0.153	0.309
Uranium-235	pCi/L	-4.19	0.00	-2.67	0	3	1.05	1.51

Surface Water Radiological Data

Table C.28 Radiological Data for Rainfall

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Tritium	pCi/L	-97.9	254	78.1	0	2	300	300

Sediment Radiological Data

Table C.29 Radiological Data for Sediment Location S1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	3.22	7.69	5.45	2	2	0.485	1.19
Americium-241	pCi/g	-0.0095	0.0059	-0.0018	0	2	0.0447	0.064
Beta activity	pCi/g	3.17	14.3	8.73	2	2	0.567	0.840
Cesium-137	pCi/g	0.013	0.0242	0.0186	1	2	0.00776	0.0222
Cobalt-60	pCi/g	-0.00074	-0.00066	-0.00070	0	2	0.00676	0.0179
Neptunium-237	pCi/g	0.0087	0.0671	0.0379	0	2	0.0167	0.0351
Plutonium-239	pCi/g	0.00953	0.0252	0.0174	1	2	0.00769	0.0102
Potassium-40	pCi/g	1.38	1.95	1.67	2	2	0.0706	0.162
Technetium-99	pCi/g	0.0348	1.16	0.597	1	2	0.18	0.192
Thorium-230	pCi/g	0.171	0.176	0.174	2	2	0.0228	0.0281
Uranium-234	pCi/g	1.7	1.7	1.7	1	1	NA	NA
Uranium-235	pCi/g	0.0944	0.0944	0.0944	1	1	NA	NA
Uranium-238	pCi/g	2.74	2.74	2.74	1	1	NA	NA

Table C.30 Radiological Data for Sediment Location S2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	3.18	3.19	3.19	2	2	0.485	1.19
Americium-241	pCi/g	0.0192	0.0683	0.0438	0	2	0.0512	0.0917
Beta activity	pCi/g	1.95	3.43	2.69	2	2	0.567	0.840
Cesium-137	pCi/g	-0.0026	0.0113	0.0044	1	2	0.00859	0.0175
Cobalt-60	pCi/g	0.00033	0.00319	0.00176	0	2	0.00769	0.0149
Neptunium-237	pCi/g	-0.00567	0.00122	-0.00223	0	2	0.0166	0.0338
Plutonium-239	pCi/g	-0.00254	0.00274	0.0001	0	2	0.00765	0.0103
Potassium-40	pCi/g	1.28	3.55	2.42	2	2	0.0706	0.108
Technetium-99	pCi/g	0.00	0.201	0.101	1	2	0.18	0.192
Thorium-230	pCi/g	0.0934	0.21	0.152	2	2	0.0229	0.0283
Uranium-234	pCi/g	0.158	0.266	0.212	2	2	NA	NA
Uranium-235	pCi/g	0.0105	0.0278	0.0192	2	2	NA	NA
Uranium-238	pCi/g	0.438	1.84	1.14	2	2	NA	NA

Sediment Radiological Data

Table C.31 Radiological Data for Sediment Location S20

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	0.819	1.36	1.09	1	2	0.485	1.19
Americium-241	pCi/g	0.0138	0.0258	0.0198	0	2	0.0364	0.0399
Beta activity	pCi/g	0.154	0.649	0.401	1	2	0.567	0.840
Cesium-137	pCi/g	0.0016	0.0043	0.0030	0	2	0.00767	0.015
Cobalt-60	pCi/g	-0.00633	0.00198	-0.00218	0	2	0.00665	0.0112
Neptunium-237	pCi/g	0.0024	0.0064	0.0044	0	2	0.0142	0.0206
Plutonium-239	pCi/g	-0.0023	0.0027	0.0002	0	2	0.00793	0.0102
Potassium-40	pCi/g	0.598	0.806	0.702	2	2	0.0582	0.141
Technetium-99	pCi/g	0.0987	0.112	0.105	0	2	0.18	0.192
Thorium-230	pCi/g	0.0806	0.0839	0.0823	2	2	0.0231	0.0281

Table C.32 Radiological Data for Sediment Location S21

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	1.95	2.93	2.55	3	3	0.485	1.19
Americium-241	pCi/g	-0.0144	0.0418	0.060	0	3	0.0535	0.0816
Beta activity	pCi/g	1.69	1.96	1.81	3	3	0.567	0.840
Cesium-137	pCi/g	0.00392	0.03210	0.0170	2	3	0.00948	0.01600
Cobalt-60	pCi/g	-0.0052	0.0078	0.0008	0	3	0.00847	0.0163
Neptunium-237	pCi/g	-0.0109	0.00056	-0.0037	0	3	0.0195	0.0304
Plutonium-239	pCi/g	-0.0011	0.0045	0.0013	0	3	0.00831	0.0102
Potassium-40	pCi/g	2.71	3.54	3.09	3	3	0.0738	0.133
Technetium-99	pCi/g	0.021	0.222	0.150	2	3	0.18	0.192
Thorium-230	pCi/g	0.213	0.319	0.261	3	3	0.0229	0.0283

Sediment Radiological Data

Table C.33 Radiological Data for Sediment Location S27

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	3.83	19.3	9.05	3	3	0.485	1.19
Americium-241	pCi/g	-0.0078	0.0689	0.0222	1	3	0.0463	0.0627
Beta activity	pCi/g	3.91	18.5	8.88	3	3	0.567	0.840
Cesium-137	pCi/g	0.0088	0.0365	0.0186	1	3	0.00673	0.023
Cobalt-60	pCi/g	-0.0104	0.00235	-0.0026	0	3	0.00687	0.0173
Neptunium-237	pCi/g	0.000474	0.0561	.019	0	3	0.0191	0.0311
Plutonium-239	pCi/g	0.0382	0.309	0.132	3	3	0.00763	0.0103
Potassium-40	pCi/g	0.366	2.34	1.66	3	3	0.057	0.178
Technetium-99	pCi/g	0.00285	37.4	12.5	1	3	0.18	0.192
Thorium-230	pCi/g	0.646	4.95	2.10	3	3	0.0233	0.0287
Uranium-234	pCi/g	0.204	2.45	0.966	3	3	NA	NA
Uranium-235	pCi/g	0.017	0.163	0.0665	3	3	NA	NA
Uranium-238	pCi/g	0.938	6.76	2.92	3	3	NA	NA

Table C.34 Radiological Data for Sediment Location S28

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	0.688	3.23	1.96	1	2	0.485	1.19
Americium-241	pCi/g	-0.0156	0.0053	-0.0051	0	2	0.0372	0.0737
Beta activity	pCi/g	0.329	1.73	1.03	1	2	0.567	0.840
Cesium-137	pCi/g	0.0024	0.0089	0.0056	0	2	0.00753	0.0166
Cobalt-60	pCi/g	-0.00211	0.00037	-0.00087	0	2	0.00623	0.0129
Neptunium-237	pCi/g	0.00513	0.00802	0.00658	0	2	0.0145	0.0288
Plutonium-239	pCi/g	-0.0013	0.0017	0.0002	0	2	0.00777	0.0102
Potassium-40	pCi/g	0.424	3.51	1.97	2	2	0.0599	0.114
Technetium-99	pCi/g	0.00	0.121	0.061	0	2	0.18	0.192
Thorium-230	pCi/g	0.0451	0.169	0.107	2	2	0.0255	0.0283

Sediment Radiological Data

Table C.35 Radiological Data for Sediment Location S30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	2.98	21.3	12.2	2	2	0.485	1.19
Americium-241	pCi/g	-0.0090	0.0261	0.0086	0	2	0.0487	0.128
Beta activity	pCi/g	3.15	39.5	21.3	2	2	0.567	0.840
Cesium-137	pCi/g	-0.00136	0.00726	0.00300	0	2	0.00965	0.0188
Cobalt-60	pCi/g	-0.00234	0.00161	-0.00037	0	2	0.00738	0.015
Neptunium-237	pCi/g	0.00452	0.00850	0.00651	0	2	0.0177	0.036
Plutonium-239	pCi/g	0.000876	0.00178	0.00133	0	2	0.00845	0.0102
Potassium-40	pCi/g	1.55	2.65	2.1	2	2	0.0748	0.134
Technetium-99	pCi/g	0.00	0.318	0.159	1	2	0.18	0.192
Thorium-230	pCi/g	0.226	0.237	0.232	2	2	0.0228	0.0291
Uranium-234	pCi/g	1.03	1.03	1.03	1	1	NA	NA
Uranium-235	pCi/g	0.212	0.212	0.212	1	1	NA	NA
Uranium-238	pCi/g	18.7	18.7	18.7	1	1	NA	NA

Table C.36 Radiological Data for Sediment Location S31

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	4.05	7.22	5.63	2	2	0.485	1.19
Americium-241	pCi/g	0.0138	0.0296	0.0217	0	2	0.0472	0.0559
Beta activity	pCi/g	4.73	8.56	6.64	2	2	0.567	0.840
Cesium-137	pCi/g	-0.00452	0.02250	0.00899	1	2	0.00952	0.0149
Cobalt-60	pCi/g	-0.00032	0.00709	0.00339	0	2	0.00877	0.0157
Neptunium-237	pCi/g	0.0056	0.0135	0.0095	0	2	0.0203	0.0231
Plutonium-239	pCi/g	0.0304	0.0331	0.0318	2	2	0.00762	0.0101
Potassium-40	pCi/g	1.49	2.24	1.87	2	2	0.0814	0.132
Technetium-99	pCi/g	0.016	0.814	0.415	1	2	0.18	0.192
Thorium-230	pCi/g	0.29	0.354	0.322	2	2	0.0231	0.0287
Uranium-234	pCi/g	1.02	2.04	1.53	2	2	NA	NA
Uranium-235	pCi/g	0.0533	0.1060	0.0797	2	2	NA	NA
Uranium-238	pCi/g	1.3	2.57	1.94	2	2	NA	NA

Sediment Radiological Data

Table C.37 Radiological Data for Sediment Location S32

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	19.4	39.4	29.4	2	2	0.485	1.19
Americium-241	pCi/g	0.315	1.31	0.813	2	2	0.0908	0.184
Beta activity	pCi/g	37.5	45.3	41.4	2	2	0.567	0.840
Cesium-137	pCi/g	0.339	1.05	0.695	2	2	0.0137	0.0268
Cobalt-60	pCi/g	-0.00545	0.00835	0.00145	0	2	0.0131	0.018
Neptunium-237	pCi/g	0.741	1.48	1.11	2	2	0.0277	0.051
Plutonium-239	pCi/g	0.0006	1.48	0.740	1	2	0.00877	0.0102
Potassium-40	pCi/g	5.33	6.96	6.15	2	2	0.105	0.177
Technetium-99	pCi/g	0	14.5	7.25	1	2	0.18	0.192
Thorium-230	pCi/g	0.235	26.1	13.1	2	2	0.0228	0.0297
Uranium-234	pCi/g	0.986	5.22	3.10	2	2	NA	NA
Uranium-235	pCi/g	0.218	0.286	0.252	2	2	NA	NA
Uranium-238	pCi/g	7.99	19.6	13.8	2	2	NA	NA

Table C.38 Radiological Data for Sediment Location S33

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	1.59	3.96	2.78	2	2	0.485	1.19
Americium-241	pCi/g	-0.0025	0.0048	0.0012	0	2	0.0387	0.0698
Beta activity	pCi/g	1.74	4.61	3.17	2	2	0.567	0.840
Cesium-137	pCi/g	0.0221	0.0638	0.0430	2	2	0.00666	0.0255
Cobalt-60	pCi/g	0.00111	0.00374	0.00243	0	2	0.00613	0.0232
Neptunium-237	pCi/g	0.0052	0.0108	0.0080	0	2	0.0149	0.0364
Plutonium-239	pCi/g	0.0122	0.0296	0.0209	2	2	0.00763	0.0102
Potassium-40	pCi/g	0.357	3.55	1.95	2	2	0.0515	0.198
Technetium-99	pCi/g	0.00	0.709	0.355	1	2	0.18	0.192
Thorium-230	pCi/g	0.0797	0.286	0.183	2	2	0.0229	0.0284
Uranium-234	pCi/g	0.621	0.621	0.621	1	1	NA	NA
Uranium-235	pCi/g	0.035	0.035	0.035	1	1	NA	NA
Uranium-238	pCi/g	1.06	1.06	1.06	1	1	NA	NA

Sediment Radiological Data

Table C.39 Radiological Data for Sediment Location S34

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Alpha activity	pCi/g	2.46	6.72	4.59	2	2	0.485	1.19
Americium-241	pCi/g	0.043	0.0876	0.0653	0	2	0.0533	0.074
Beta activity	pCi/g	2.88	11.4	7.14	2	2	0.567	0.840
Cesium-137	pCi/g	0.0000	0.0003	0.0002	0	2	0.0139	0.019
Cobalt-60	pCi/g	-0.00046	0.00484	0.00219	0	2	0.0116	0.0146
Neptunium-237	pCi/g	0.0122	0.0471	0.0297	0	2	0.026	0.0315
Plutonium-239	pCi/g	0.0415	0.0503	0.0459	2	2	0.00798	0.0104
Potassium-40	pCi/g	0.586	3.3	1.94	2	2	0.101	0.161
Technetium-99	pCi/g	0.0131	1.76	0.887	1	2	0.18	0.192
Thorium-230	pCi/g	1.31	1.81	1.56	2	2	0.0232	0.0282
Uranium-234	pCi/g	0.672	0.672	0.672	1	1	NA	NA
Uranium-235	pCi/g	0.0429	0.0429	0.0429	1	1	NA	NA
Uranium-238	pCi/g	1.67	1.67	1.67	1	1	NA	NA

Deer Radiological Data

Table C.40 Radiological Analysis of Deer Bone Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	-2.56	2.71	0.438	0	9	5.69	6.31
Neptunium-237	pCi/g	0.00	0.045	0.025	0	9	0.027	0.098
Plutonium-239	pCi/g	0.00	0.037	0.02	0	9	0.025	0.16
Strontium-90	pCi/g	0.10	1.3	0.711	0	9	1.6	1.6
Technetium-99	pCi/g	-0.2	0.00	-0.1	0	9	0.1	0.1
Thorium-230	pCi/g	0.024	0.49	0.193	3	9	0.079	1.3
Uranium-234	pCi/g	-0.033	0.082	0.029	1	9	0.02	0.12
Uranium-235	pCi/g	-0.017	0.019	0.061	0	9	0.022	0.094
Uranium-238	pCi/g	-0.0000011	0.052	0.014	1	9	0.019	0.051

Table C.41 Radiological Background (BWMA) Analysis of Deer Bone Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	-1.14	-0.09	-0.615	0	2	6	6.16
Neptunium-237	pCi/g	0.02	0.07	0.05	0	2	0.027	0.073
Plutonium-239	pCi/g	0.003	0.03	0.017	0	2	0.027	0.036
Strontium-90	pCi/g	0.7	1.4	1.05	0	2	1.6	1.6
Technetium-99	pCi/g	-0.3	-0.1	-0.2	0	2	0.1	0.3
Thorium-230	pCi/g	0.28	1.1	0.69	1	2	0.53	0.83
Uranium-234	pCi/g	0.000	0.058	0.029	1	2	0.048	0.1
Uranium-235	pCi/g	-0.0082	0.016	0.0039	0	2	0.022	0.061
Uranium-238	pCi/g	0.0000	0.0065	0.00325	0	2	0.017	0.062

Table C.42 Radiological Analysis of Deer Muscle Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	-0.36	0.95	0.116	0	9	1.44	1.6
Neptunium-237	pCi/g	-0.019	0.027	0.008	0	9	0.0089	0.067
Plutonium-239	pCi/g	-0.011	0.019	0.007	0	9	0.0085	0.046
Technetium-99	pCi/g	0.00	0.10	0.02	0	9	0.1	0.1
Thorium-230	pCi/g	0.0029	0.039	0.0264	1	9	0.0093	0.073
Uranium-234	pCi/g	0.019	0.065	0.0376	9	9	0.0085	0.025
Uranium-235	pCi/g	0.0039	0.0044	0.0041	0	9	0.011	0.032
Uranium-238	pCi/g	0.0033	0.021	0.011	2	9	0.0085	0.025

Deer Radiological Data

Table C.43 Radiological Background (BWMA) Analysis of Deer Muscle Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	0.70	1.09	0.895	0	2	1.56	1.57
Neptunium-237	pCi/g	0.014	0.017	0.016	0	2	0.026	0.035
Plutonium-239	pCi/g	0.0089	0.012	0.0105	0	2	0.012	0.041
Technetium-99	pCi/g	0.0	0.0	0.0	0	2	0.1	0.1
Thorium-230	pCi/g	0.013	0.036	0.025	1	2	0.0082	0.025
Uranium-234	pCi/g	0.0096	0.017	0.013	1	2	0.0093	0.038
Uranium-235	pCi/g	0.0079	0.013	0.0105	0	2	0.011	0.031
Uranium-238	pCi/g	0.014	0.019	0.017	1	2	0.0087	0.0092

Table C.44 Radiological Analysis of Deer Liver Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	-0.36	2.23	0.361	1	9	1.43	1.59
Neptunium-237	pCi/g	-0.014	0.012	0.000	0	9	0.025	0.29
Plutonium-239	pCi/g	0.002	0.016	0.009	0	9	0.0095	0.055
Technetium-99	pCi/g	-0.10	0.00	-0.022	0	9	0.1	0.1
Thorium-230	pCi/g	-0.017	0.46	0.148	6	9	0.025	0.092
Uranium-234	pCi/g	-0.0098	0.067	0.015	1	9	0.022	0.06
Uranium-235	pCi/g	-0.015	0.0079	0.0000	0	9	0.0097	0.05
Uranium-238	pCi/g	-0.012	0.02	0.001	0	9	0.021	0.04

Table C.45 Radiological Background (BWMA) Analysis of Deer Liver Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Cesium-137	pCi/g	-0.24	-0.16	-0.2	0	2	1.39	1.48
Neptunium-237	pCi/g	0.0074	0.011	0.0092	0	2	0.034	0.052
Plutonium-239	pCi/g	0.0015	0.0037	0.0026	0	2	0.027	0.047
Technetium-99	pCi/g	-0.1	-0.1	-0.1	0	2	0.1	0.1
Thorium-230	pCi/g	-0.015	0.10	0.04	1	2	0.044	0.056
Uranium-234	pCi/g	0.014	0.30	0.157	1	2	0.034	0.037
Uranium-235	pCi/g	0.0035	0.015	0.0093	0	2	0.01	0.026
Uranium-238	pCi/g	-0.0057	0.043	0.0187	1	2	0.023	0.026

Deer Radiological Data

Table C.46 Radiological Analysis of Deer Thyroid Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Technetium-99	pCi/g	-0.3	0.1	-0.1	0	2	0.5	0.7

Table C.47 Radiological Background (BWMA) Analysis of Deer Thyroid Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Technetium-99	pCi/g	-0.1	0.1	0	0	2	0.3	0.5

Fish Tissue Radiological Data

Table C.48 Radiological Analysis of Fish Tissue for 2000 at Location LUK 7.2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Bismuth-214	pCi/g	0.546	0.546	0.546	1	1	0.0846	0.0846
Lead-214	pCi/g	0.58	0.58	0.58	1	1	0.103	0.103
Potassium-40	pCi/g	0.336	0.336	0.336	0	1	0.487	0.487
Thorium-228	pCi/g	0.453	0.453	0.453	1	1	0.0759	0.0759
Thorium-234	pCi/g	5.98	5.98	5.98	1	1	0.943	0.943
Uranium-234	pCi/g	2.15	2.15	2.15	0	1	0.654	0.654
Uranium-238	pCi/g	6.54	6.54	6.54	0	1	1.98	1.98

Table C.49 Radiological Analysis of Fish Tissue for 2000 at Location BBK 9.1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Bismuth-212	pCi/g	0.524	0.524	0.524	1	1	0.219	0.219
Potassium-40	pCi/g	0.682	0.682	0.682	1	1	0.351	0.351
Radium-226	pCi/g	0.409	0.409	0.409	1	1	0.168	0.168

Table C.50 Radiological Analysis of Fish Tissue for 2000 at Location BBK 10.0

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Potassium-40	pCi/g	3.29	3.29	3.29	1	1	0.92	0.92
Radium-226	pCi/g	0.487	0.487	0.487	1	1	0.194	0.194
Thorium-228	pCi/g	0.224	0.224	0.224	1	1	0.0804	0.0804

Table C.51 Radiological Analysis of Fish Tissue for 2000 at Location BBK 12.5

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Bismuth-214	pCi/g	0.412	0.412	0.412	1	1	0.07	0.07
Lead-214	pCi/g	0.444	0.444	0.444	1	1	0.0739	0.0739
Potassium-40	pCi/g	0.925	0.925	0.925	1	1	0.386	0.386
Thorium-228	pCi/g	0.217	0.217	0.217	1	1	0.0688	0.0688

Drum Mountain Area Radiological Mammal Data

Table C.52 Radiological Analysis of Small Mammal Tissue (Vole/Lemming) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/g	-0.499	-0.499	-0.499	0	1	1.01	1.01
Cesium-137	pCi/g	0.0737	2.41	1.24	0	2	0.494	10.9
Cobalt-60	pCi/g	0.0145	0.0145	0.0145	0	1	0.457	0.457
Neptunium-237	pCi/g	0.0417	0.100	0.0709	1	2	0.046	0.611
Plutonium-239	pCi/g	0.0071	0.0071	0.0071	0	1	0.037	0.037
Technetium-99	pCi/g	11.7	11.7	11.7	1	1	0.1	0.1
Thorium-230	pCi/g	0.055	0.055	0.055	1	1	0.038	0.038
Uranium-234	pCi/g	0.061	0.061	0.061	1	1	0.037	0.037
Uranium-235	pCi/g	0.011	0.011	0.011	0	1	0.015	0.015
Uranium-238	pCi/g	0.38	0.38	0.38	1	1	0.03	0.03

Table C.53 Radiological Analysis of Small Mammal Tissue (Mouse) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/g	-0.533	-0.154	-0.344	0	2	1.04	1.12
Cesium-137	pCi/g	-0.25	0.57	0.081	0	4	0.308	3.06
Cobalt-60	pCi/g	0.000	0.0053	0.0026	0	2	0.112	0.351
Neptunium-237	pCi/g	-0.0068	0.203	0.0667	0	4	0.03	0.633
Plutonium-239	pCi/g	-0.0052	0.000	-0.0026	0	2	0.016	0.03
Potassium-40	pCi/g	7.26	7.26	7.26	1	1	1.04	1.04
Technetium-99	pCi/g	1.7	4.14	2.92	2	2	0.1	0.1
Thorium-230	pCi/g	0.027	0.033	0.030	1	2	0.028	0.053
Uranium-234	pCi/g	0.71	1.2	0.955	2	2	0.041	0.076
Uranium-235	pCi/g	0.055	0.11	0.083	2	2	0.017	0.063
Uranium-238	pCi/g	2.8	4.1	3.45	2	2	0.041	0.071

Drum Mountain Area Radiological Mammal Data

Table C.54 Radiological Analysis of Small Mammal Tissue (Opossum) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/g	-6.49	0.559	-1.49	0	4	0.711	7.61
Cesium-137	pCi/g	-1.02	2.44	0.10	0	8	0.253	23
Cobalt-60	pCi/g	-0.809	0.135	-0.192	0	4	0.147	1.18
Neptunium-237	pCi/g	-0.177	1.12	0.141	0	7	0.038	5.63
Plutonium-239	pCi/g	0.0012	0.0095	0.0040	0	3	0.029	0.031
Strontium-90	pCi/g	0.7	0.7	0.7	0	1	0.8	0.8
Technetium-99	pCi/g	-0.15	0.02	-0.065	0	4	0.1	0.5
Thorium-230	pCi/g	0.014	0.025	0.020	0	3	0.026	0.053
Uranium-234	pCi/g	-0.018	-0.0048	-0.0102	0	3	0.061	0.076
Uranium-235	pCi/g	-0.0069	-0.0024	-0.0044	0	3	0.036	0.045
Uranium-238	pCi/g	-0.0034	0.003	0.0000	0	3	0.041	0.054

Table C.55 Radiological Analysis of Small Mammal Tissue (Raccoon 1) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/g	-0.702	0.302	-0.065	0	5	0.0159	2.25
Cesium-137	pCi/g	-2.13	0.0641	-0.491	0	9	0.0257	6.6
Cobalt-60	pCi/g	-0.126	0.0075	-0.0291	0	5	0.0269	0.798
Neptunium-237	pCi/g	-0.325	0.121	-0.047	0	9	0.013	1.29
Plutonium-239	pCi/g	0.0014	0.020	0.0093	0	4	0.0098	0.041
Strontium-90	pCi/g	0.1	0.1	0.1	0	1	0.8	0.8
Technetium-99	pCi/g	-0.12	1.47	0.38	2	4	0.1	0.1
Thorium-230	pCi/g	-0.0034	0.031	0.0153	0	4	0.039	0.063
Uranium-234	pCi/g	0.002	0.26	0.11	2	4	0.031	0.071
Uranium-235	pCi/g	-0.0025	0.01	0.0038	0	4	0.016	0.048
Uranium-238	pCi/g	0.014	0.46	0.233	2	4	0.031	0.047

Drum Mountain Area Radiological Mammal Data

Table C.56 Radiological Analysis of Small Mammal Tissue (Raccoon 2) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Americium-241	pCi/g	-0.342	0.0362	-0.113	0	5	0.764	34.3
Cesium-137	pCi/g	-2.65	1.71	-0.361	0	9	0.249	10.6
Cobalt-60	pCi/g	0.00	0.13	0.060	0	5	0.366	5.61
Neptunium-237	pCi/g	-0.0842	4.34	0.480	0	9	0.01	17.3
Plutonium-239	pCi/g	-0.0009	0.02	0.0070	0	4	0.0099	0.054
Strontium-90	pCi/g	0.6	0.6	0.6	1	1	0.6	0.6
Technetium-99	pCi/g	-0.02	0.57	0.163	1	4	0.1	0.1
Thorium-230	pCi/g	0.0056	0.029	0.013	1	4	0.021	0.064
Uranium-234	pCi/g	-0.002	0.17	0.092	2	4	0.044	0.075
Uranium-235	pCi/g	0.0021	0.016	0.0102	0	4	0.013	0.05
Uranium-238	pCi/g	0.017	0.34	0.168	2	4	0.011	0.058

Direct Gamma Radiation (TLD) Data

Table C.57 Radiological Exposure Due to Gamma Radiation (mrem)

Location	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	Annualized[1]
TLD-1	84	110	98	120	423
TLD-2	160	195	175	200	751
TLD-3	66	76	44	270	470
TLD-4	24	23	22	25	97
TLD-5	24	24	23	26	100
TLD-6	24	21	20	24	92
TLD-7	27	26	25	28	114
TLD-8	--	--	14	20	75
TLD-9	23	24	22	26	103
TLD-10	21	20	18	22	87
TLD-11	23	22	21	24	97
TLD-12	22	21	21	22	93
TLD-13	25	25	23	28	109
TLD-14	21	20	19	21	87
TLD-15	21	20	17	19	83
TLD-16	26	23.5	22	25	104
TLD-17	21	19	18	21	85
TLD-18	21	20	20	22	90
TLD-19	22	21	19	23	92
TLD-20	23	24	22	25	102
TLD-24	24	21	20	23	92
TLD-25	26	29	27	30	121
TLD-27	--	--	23	26	101
TLD-28	--	--	16	24	86
TLD-29	--	--	14	22	78
TLD-30	--	--	16	23	84
TLD-31	--	--	18	24	91
TLD-32	--	--	19	--	101
TLD-33	--	--	19	29	104
TLD-34	--	--	18	27	97
TLD-35	--	--	15	23	82
TLD-36	--	--	14	21	76
TLD-37	--	--	14	21	76
TLD-38	--	--	14	--	74
TLD-39	--	--	14	21	76
TLD-40	--	--	18	--	98
TLD-41	--	--	14	20	75
TLD-42	--	--	16	24	88
TLD-43	--	--	19	26	99
TLD-44	--	--	39	49	184
TLD-45	--	--	15	23	86
TLD-46	--	--	19	23	95
Background					
TLD-21	25	26	25	29	111
TLD-22	27	25	19	27	100
TLD-23	24	25	22	28	102
TLD-26	27	28	20	24	107

[1]Note: Annualized results represent a summation of the quarters adjusted to ensure that there is a correlation between the results and 1 year (365 days). TLDs may not have been collected on the last day of each quarter so this accounts for varying number of days within the sampling period.
-- No Data

Project Radiological Ambient Air Monitoring

Table C.58 Ambient Air Data Collected During Drum Mountain Removal

Ratio of Maximum Air Concentration to Allowable Concentration

Nuclide	Monitor 1	Monitor 2	Monitor 3	Monitor 4
Americium-241	0.002068	0.005579	0.012172	0.001357
Beryllium-7	0.000720	0.000534	0.000575	0.000431
Cesium-137	0.000952	0.000884	0.001701	0.001138
Cobalt-60	0.003031	0.001847	0.003398	0.001519
Lead-212	0.000010	0.000013	0.000011	0.000012
Lead-214	0.000001	NA	NA	0.000001
Neptunium-237	0.035446	0.027153	0.072370	0.019115
Plutonium-238	0.011158	0.007868	0.053413	0.012804
Plutonium-239/240	0.003832	0.004466	0.015476	0.004647
Potassium-40	0.031657	0.031410	0.048995	0.038638
Protactinium-234m	NA	0.000058	0.000036	0.000059
Radium-226	NA	0.042766	0.028968	NA
Technetium-99	0.012964	0.014666	0.006914	0.005875
Thorium-228	0.031187	0.046149	0.044325	0.019787
Thorium-230	0.136050	0.007291	0.018791	0.010677
Thorium-232	0.106303	0.030602	0.017475	0.015417
Thorium-234	--	--	0.000210	0.000144
Uranium-234	--	--	0.160580	0.133295
Uranium-235	--	--	0.048270	0.032152
Uranium-238	--	--	0.061802	0.062145

NA - Not Applicable
-- No Data

(The ratio is the maximum measured concentration for the duration of the project regulatory divided by allowable concentration).

Project Radiological Ambient Air Monitoring

Table C.59 Kentucky Radiation Health and Toxics Branch Air Monitoring

	AMSW017	AMW015	AMNW001	AMN003	AMNE	AME002	AME012	AMBKG1/2
Nuclide	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3	Ci/m3
Am-241	3.767E-16	2.061E-16	3.937E-17	8.811E-17	2.624E-16	1.445E-16	2.096E-16	1.714E-16
Np-237	2.058E-16	2.108E-16	3.48E-16	-6.888E-17	2.456E-16	-3.403E-17	-1.667E-16	8.563E-18
Tc-99	2E-16	-5E-16	-1.1E-15	0	-3E-16	2E-16	-2E-16	-4E-16
U-238/Th-234	-1.867E-15	4.452E-15	6.607E-16	3.709E-15	-3.019E-15	-1.938E-15	-6.242E-16	-7.278E-16
Sum of ratios	0.15	0.82	0.38	0.44	-0.02	-0.18	-0.11	0.01
Am-241	-5.919E-16	-1.409E-16	-1.699E-16	-1.006E-16	-9.572E-17	-8.25E-17	5.315E-17	-2.604E-16
Np-237	3.553E-16	-1.669E-16	-1.609E-16	-7.256E-17	-4.833E-16	-8.899E-18	1.044E-16	3.947E-18
Tc-99	7E-16	-1E-16	2E-16	7E-16	2E-16	1E-16	0	7E-16
U-238/Th-234	9.488E-16	-2.872E-15	-6.179E-15	-1.806E-15	-3.116E-15	-7.661E-16	-1.276E-15	-1.256E-15
Sum of ratios	0.10	-0.56	-0.97	-0.33	-0.83	-0.14	-0.04	-0.28
Am-241	5.915E-17	-5.321E-16	-3.971E-16	-2.216E-16	-7.819E-16	-2.147E-15	-4.761E-16	-3.691E-16
Np-237	-2.87E-16	-1.28E-16	4.501E-17	1.897E-17	2.08E-16	-1.454E-16	-4.04E-16	3.592E-18
Tc-99	1.4E-15	7E-16	1.3E-15	9E-16	8E-16	1.5E-15	8E-16	4E-16
U-238/Th-234	4.985E-16	-3.734E-15	6.098E-15	-2.71E-15	-6.345E-15	-3.769E-15	-6.451E-15	-3.67E-15
Sum of ratios	-0.14	-0.83	0.57	-0.42	-1.00	-1.69	-1.36	-0.63
Am-241	-3.514E-16	-3.349E-16	-1.492E-16	-1.555E-16	-7.648E-17	-4.66E-16	-2.013E-16	-3.279E-16
Np-237	2.8E-17	-9.98E-17	-7.669E-17	2.13E-16	-2.215E-16	3.228E-16	-2.862E-16	-2.091E-16
Tc-99	5E-16	1E-15	5E-16	7E-16	1.1E-15	1.2E-15	1.2E-15	5E-16
U-238/Th-234	1.357E-15	1.111E-15	-6.716E-16	-2.564E-15	-2.177E-15	-1.329E-15	1.518E-15	-3.87E-15
Sum of ratios	0.01	-0.12	-0.22	-0.21	-0.48	-0.13	-0.15	-0.81

"Sum of Ratios": The ratio of the measured concentration to the allowable concentration is added for all radionuclides for each quarter for each location. A value of less than one indicates regulatory compliance.

KPDES Outfall Non-Radiological Data

Table C.60 Non-Radiological Effluent Data for Outfall 001

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Antimony	mg/L	ND	ND	ND	0	6	0.2	0.2
Arsenic	mg/L	ND	ND	ND	0	6	0.2	0.2
Beryllium	mg/L	ND	ND	ND	0	6	0.005	0.01
Cadmium	mg/L	ND	0.021	0.010	1	6	0.01	0.02
Chlorine, Total Residual	mg/L	ND	0.07	0.016	1	89	NA	NA
Chromium	mg/L	ND	ND	ND	0	6	0.025	0.05
Conductivity	umho/c	390	2230	1080	95	95	NA	NA
Copper	mg/L	ND	ND	ND	0	6	0.025	0.05
Dissolved Oxygen	mg/L	5.33	12.9	8.82	95	95	NA	NA
Flow Rate	mgd	0.44	8	1.9	96	96	NA	NA
Hardness - Total as CaCO3	mg/L	59	452	284	14	14	15	20
Iron	mg/L	0.271	1.3	0.636	6	6	0.2	0.2
Lead	mg/L	ND	ND	ND	0	6	0.2	0.2
Mercury	mg/L	ND	ND	ND	0	6	0.0002	0.0002
Nickel	mg/L	ND	ND	ND	0	6	0.025	0.05
Oil and Grease	mg/L	ND	ND	ND	0	52	5	5
PCB-1016	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	15	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	15	0.17	0.17
pH	Std Unit	6.8	8.79	7.58	96	96	NA	NA
Phosphorous	mg/L	ND	0.33	0.172	51	52	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	15	0.17	0.17
Selenium	mg/L	ND	ND	ND	0	6	0.2	0.2
Silver	mg/L	ND	ND	ND	0	6	0.025	0.05
Temperature	deg F	42.2	84.1	65.1	96	96	NA	NA
Thallium	mg/L	ND	ND	ND	0	6	0.2	0.2
Trichloroethene	ug/L	ND	ND	ND	0	14	1	1
Uranium	mg/L	0.002	0.06	0.03	5	5	0.001	0.001
Zinc	mg/L	ND	0.205	0.118	1	6	0.2	0.2

NA = Not Applicable

ND = Non Detect

KPDES Outfall Non-Radiological Data

Table C.61 Non-Radiological Effluent Data for Outfall 015

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Antimony	mg/L	ND	ND	ND	0	4	0.2	0.2
Arsenic	mg/L	ND	ND	ND	0	4	0.2	0.2
Beryllium	mg/L	ND	ND	ND	0	4	0.005	0.01
Cadmium	mg/L	ND	ND	ND	0	4	0.01	0.02
Chlorine, Total Residual	mg/L	ND	ND	ND	0	7	NA	NA
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	157	715	355	29	29	NA	NA
Copper	mg/L	ND	ND	ND	0	4	0.025	0.05
Dissolved Oxygen	mg/L	4.96	9.32	7.83	29	29	NA	NA
Flow Rate	mgd	0.01	4.57	0.74	29	29	NA	NA
Hardness - Total as CaCO3	mg/L	67	236	148	12	12	15	20
Iron	mg/L	0.388	1.21	0.772	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Mercury	mg/L	ND	ND	ND	0	4	0.0002	0.0002
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
Oil and Grease	mg/L	ND	ND	ND	0	12	5	5
PCB-1016	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	12	0.17	0.17
pH	Std Unit	7.3	8.3	7.67	29	29	NA	NA
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	12	0.17	0.17
Selenium	mg/L	ND	ND	ND	0	4	0.2	0.2
Silver	mg/L	ND	ND	ND	0	4	0.025	0.05
Temperature	deg F	43.1	72.8	59.5	29	29	NA	NA
Thallium	mg/L	ND	ND	ND	0	4	0.2	0.2
Uranium	mg/L	0.012	0.26	0.090	4	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable

ND = Non Detect

KPDES Outfall Non-Radiological Data

Table C.62 Non-Radiological Effluent Data for Outfall 017

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Antimony	mg/L	ND	ND	ND	0	5	0.2	0.2
Arsenic	mg/L	ND	ND	ND	0	5	0.2	0.2
Beryllium	mg/L	ND	ND	ND	0	5	0.005	0.01
Cadmium	mg/L	ND	ND	ND	0	5	0.01	0.02
Chlorine, Total Residual	mg/L	ND	ND	ND	0	9	NA	NA
Chromium	mg/L	ND	ND	ND	0	5	0.025	0.05
Conductivity	umho/c	73.1	559	239	37	37	NA	NA
Copper	mg/L	ND	ND	ND	0	5	0.025	0.05
Dissolved Oxygen	mg/L	4.8	10.0	7.36	37	37	NA	NA
Flow Rate	mgd	0.01	16.6	1.6	37	37	NA	NA
Hardness - Total as CaCO3	mg/L	31	186	83.8	16	16	15	20
Iron	mg/L	0.276	0.577	0.368	5	5	0.2	0.2
Lead	mg/L	ND	ND	ND	0	5	0.2	0.2
Mercury	mg/L	ND	ND	ND	0	5	0.0002	0.0002
Nickel	mg/L	ND	ND	ND	0	5	0.025	0.05
Oil and Grease	mg/L	ND	ND	ND	0	12	5	5
PCB-1016	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	12	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	12	0.17	0.17
pH	Std Unit	7	8.59	7.69	37	37	NA	NA
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	12	0.17	0.17
Selenium	mg/L	ND	ND	ND	0	5	0.2	0.2
Silver	mg/L	ND	ND	ND	0	5	0.025	0.05
Suspended Solids	mg/L	ND	ND	ND	0	4	24	24
Temperature	deg F	43.7	81.4	62.5	37	37	NA	NA
Thallium	mg/L	ND	ND	ND	0	5	0.2	0.2
Uranium	mg/L	ND	0.003	0.002	4	5	0.001	0.001
Zinc	mg/L	ND	0.302	0.174	4	9	0.2	0.2
Zinc, Dissolved	mg/L	ND	0.21	0.128	1	4	0.2	0.2

NA = Not Applicable
ND = Non Detect

KPDES Outfall Non-Radiological Data

Table C.63 Non-Radiological Effluent Data for Outfall 019

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Antimony	mg/L	ND	ND	ND	0	3	0.2	0.2
Arsenic	mg/L	ND	ND	ND	0	3	0.2	0.2
Beryllium	mg/L	ND	ND	ND	0	3	0.005	0.01
Cadmium	mg/L	ND	ND	ND	0	3	0.01	0.02
Chlorine, Total Residual	mg/L	ND	ND	ND	0	4	NA	NA
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.05
Conductivity	umho/c	106	158	128	10	10	NA	NA
Copper	mg/L	ND	0.05	0.031	1	3	0.025	0.05
Dissolved Oxygen	mg/L	6.9	15.2	9.69	10	10	NA	NA
Flow Rate	mgd	0.8	1.25	1.1	10	10	NA	NA
Hardness - Total as CaCO3	mg/L	45	67	56.7	3	3	20	20
Iron	mg/L	0.458	0.601	0.539	3	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Mercury	mg/L	ND	ND	ND	0	3	0.0002	0.0002
Nickel	mg/L	ND	ND	ND	0	3	0.05	0.05
Oil and Grease	mg/L	ND	ND	ND	0	3	5	5
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	8.67	8.82	8.75	10	10	NA	NA
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Selenium	mg/L	ND	ND	ND	0	3	0.2	0.2
Silver	mg/L	ND	ND	ND	0	3	0.025	0.05
Suspended Solids	mg/L	ND	24	9.67	1	3	10	24
Temperature	deg F	39	56.8	46.0	10	10	NA	NA
Thallium	mg/L	ND	ND	ND	0	3	0.2	0.2
Uranium	mg/L	ND	ND	ND	0	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.64 Non-Radiological Effluent Data for Surface Water Location L1

Upstream Bayou Creek (Background)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	5	1000	1000
Acetone	ug/L	ND	ND	ND	0	5	1000	1000
Aluminum	mg/L	ND	0.642	0.40	4	5	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	5	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	5	10	10
Chloride	mg/L	11.8	16.9	13.6	5	5	2	2
Chromium	mg/L	ND	ND	ND	0	5	0.025	0.05
Conductivity	umho/c	207	246	223	5	5	NA	NA
Copper	mg/L	ND	ND	ND	0	5	0.025	0.05
Dissolved Oxygen	mg/L	5.83	9.4	7.8	5	5	NA	NA
Flow Rate	mgd	0.18	0.84	0.53	5	5	NA	NA
Hardness - Total as CaCO3	mg/L	48	71	61	5	5	20	20
Iron	mg/L	0.217	0.643	0.506	5	5	0.2	0.2
Lead	mg/L	ND	ND	ND	0	5	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	5	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	5	0.17	0.17
pH	Std Unit	7.22	7.71	7.49	5	5	NA	NA
Phosphorous	mg/L	ND	0.18	0.12	4	5	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	5	10	24
Temperature	deg F	44.5	82.3	60.7	5	5	NA	NA
Trichloroethene	ug/L	ND	1	0.6	1	5	1	1
Uranium	mg/L	ND	ND	ND	0	5	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	5	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.65 Non-Radiological Effluent Data for Surface Water Location L5

Downstream Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	ND	0.377	0.21	2	4	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	4	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	25.7	123	56.2	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	277	1030	549	4	4	NA	NA
Copper	mg/L	ND	ND	ND	0	4	0.025	0.05
Dissolved Oxygen	mg/L	5.69	15.7	9.72	4	4	NA	NA
Flow Rate	mgd	5.48	17.3	11	4	4	NA	NA
Hardness - Total as CaCO3	mg/L	68	260	133	4	4	20	20
Iron	mg/L	0.225	0.478	0.355	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.2	8.9	7.78	4	4	NA	NA
Phosphorous	mg/L	0.06	0.16	0.11	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	4	10	25
Temperature	deg F	51.2	84.7	65.4	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	ND	0.023	0.009	3	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable
ND = Non Detect

Surface Water Non-Radiological Data

Table C.66 Non-Radiological Effluent Data for Surface Water Location L6

Downstream of Plant Effluents in Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	3	1000	1000
Acetone	ug/L	ND	ND	ND	0	3	1000	1000
Aluminum	mg/L	ND	0.649	0.35	2	3	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	3	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	3	10	10
Chloride	mg/L	22.9	47	32.8	3	3	2	2
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.025
Conductivity	umho/c	288	517	378	3	3	NA	NA
Copper	mg/L	ND	0.027	0.017	1	3	0.025	0.025
Dissolved Oxygen	mg/L	6.44	10.8	8.52	3	3	NA	NA
Flow Rate	mgd	0.98	8.49	5.5	3	3	NA	NA
Hardness - Total as CaCO3	mg/L	74	125	94	3	3	20	20
Iron	mg/L	ND	0.562	0.367	2	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	3	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	7.23	7.5	7.39	3	3	NA	NA
Phosphorous	mg/L	0.07	0.13	0.010	3	3	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	3	11	25
Temperature	deg F	49.4	88.5	70.4	3	3	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	3	1	1
Uranium	mg/L	0.001	0.016	0.008	3	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable
ND = Non Detect

Table C.67 Non-Radiological Effluent Data for Surface Water Location L8

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Conductivity	umho/c	186	584	367	4	4	NA	NA
Dissolved Oxygen	mg/L	7.34	13.1	9.93	4	4	NA	NA
Flow Rate	mgd	0.32	7.69	4.0	2	2	NA	NA
pH	Std Unit	7.4	7.7	7.53	4	4	NA	NA
Temperature	deg F	45.5	86.4	64.3	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1

NA = Not Applicable ND = Non Detect

Surface Water Non-Radiological Data

Table C.68 Non-Radiological Effluent Data for Surface Water Location L10

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	5	1000	1000
Acetone	ug/L	ND	ND	ND	0	5	1000	1000
Aluminum	mg/L	ND	0.97	0.36	3	5	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	5	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	5	10	10
Chloride	mg/L	22.1	37.2	31.3	5	5	2	2
Chromium	mg/L	ND	ND	ND	0	5	0.025	0.05
Conductivity	umho/c	272	444	360	5	5	NA	NA
Copper	mg/L	ND	ND	ND	0	5	0.025	0.05
Dissolved Oxygen	mg/L	5.08	11.3	7.99	5	5	NA	NA
Flow Rate	mgd	0.29	1.18	0.69	5	5	NA	NA
Hardness - Total as CaCO3	mg/L	65	114	90	5	5	20	20
Iron	mg/L	0.348	0.892	0.485	5	5	0.2	0.2
Lead	mg/L	ND	ND	ND	0	5	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	5	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	5	0.17	0.17
pH	Std Unit	7.2	7.7	7.47	5	5	NA	NA
Phosphorous	mg/L	0.17	0.34	0.22	5	5	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	5	10	24
Temperature	deg F	50.3	79.3	60.3	5	5	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	5	1	1
Uranium	mg/L	0.003	0.022	0.010	5	5	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	5	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.69 Non-Radiological Effluent Data for Surface Water Location L11

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	ND	4.92	1.52	3	4	0.2	0.2
Cadmium	mg/L	ND	0.026	0.013	1	4	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	10.7	32.5	21.4	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	199	372	280	4	4	NA	NA
Copper	mg/L	ND	0.05	0.02	1	4	0.025	0.05
Dissolved Oxygen	mg/L	5.75	11.5	8.14	4	4	NA	NA
Flow Rate	mgd	0.81	2.35	1.6	4	4	NA	NA
Hardness - Total as CaCO3	mg/L	65	87	76	4	4	20	20
Iron	mg/L	0.452	3.59	1.40	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.24	8	7.52	4	4	NA	NA
Phosphorous	mg/L	0.09	0.51	0.27	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	4	10	24
Temperature	deg F	43.2	84.8	60.2	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	0.004	0.017	0.009	4	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable
ND = Non Detect

Table C.70 Non-Radiological Effluent Data for Surface Water Location L12

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Conductivity	umho/c	174	348	288	4	4	NA	NA
Dissolved Oxygen	mg/L	7.42	11.0	8.45	4	4	NA	NA
Flow Rate	mgd	0.2	2.8	1.5	4	4	NA	NA
pH	Std Unit	6.81	7.35	7.12	4	4	NA	NA
Temperature	deg F	48.6	77.5	60.7	4	4	NA	NA
Trichloroethene	ug/L	ND	2	1.3	2	4	1	1

NA = Not Applicable
ND = Non Detect

Surface Water Non-Radiological Data

Table C.71 Non-Radiological Effluent Data for Surface Water Location L29

Upstream Ohio River (Reference)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	0.294	2.71	1.09	4	4	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	4	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	11.9	27.7	19.0	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	190	327	287	4	4	NA	NA
Copper	mg/L	ND	0.06	0.024	1	4	0.025	0.05
Dissolved Oxygen	mg/L	8.04	14.3	10.4	4	4	NA	NA
Hardness - Total as CaCO3	mg/L	63	164	123	4	4	20	20
Iron	mg/L	0.464	2.22	1.05	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.4	8.3	7.83	4	4	NA	NA
Phosphorous	mg/L	0.05	0.11	0.085	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	70	31	3	4	10	24
Temperature	deg F	37.4	84.5	60.2	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	ND	ND	ND	0	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.72 Non-Radiological Effluent Data for Surface Water Location L30

Downstream Ohio River

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	0.488	2.23	1.25	4	4	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	4	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	12.5	28.1	19	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	187	394	302	4	4	NA	NA
Copper	mg/L	ND	0.057	0.029	2	4	0.025	0.05
Dissolved Oxygen	mg/L	6.02	12.5	9.25	4	4	NA	NA
Hardness - Total as CaCO3	mg/L	77	165	127	4	4	20	20
Iron	mg/L	0.539	3.75	1.67	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.7	8.1	7.9	4	4	NA	NA
Phosphorous	mg/L	0.07	0.11	0.088	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	53	36	3	4	10	25
Temperature	deg F	46.7	85.8	63.8	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	ND	0.001	0.001	1	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.73 Non-Radiological Effluent Data for Surface Water Location L55

Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	1.89	2.91	2.21	4	4	0.2	0.2
Cadmium	mg/L	ND	0.024	0.02	2	4	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	23.8	42.4	30.7	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.025
Conductivity	umho/c	365	505	411	4	4	NA	NA
Copper	mg/L	ND	ND	ND	0	4	0.025	0.025
Dissolved Oxygen	mg/L	6.47	9.77	8.52	4	4	NA	NA
Flow Rate	mgd	0.16	1.99	0.65	4	4	NA	NA
Hardness - Total as CaCO3	mg/L	104	140	122	4	4	20	20
Iron	mg/L	1.42	2.37	1.91	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.2	7.41	7.35	4	4	NA	NA
Phosphorous	mg/L	0.06	0.3	0.2	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	26	19	2	4	11	24
Temperature	deg F	48.6	74	59.8	4	4	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	0.003	0.01	0.008	4	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.74 Non-Radiological Effluent Data for Surface Water Location L56

Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	3	1000	1000
Acetone	ug/L	ND	ND	ND	0	3	1000	1000
Aluminum	mg/L	0.215	1.8	1.06	3	3	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	3	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	3	10	10
Chloride	mg/L	29.3	48.8	36.7	3	3	2	2
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.025
Conductivity	umho/c	381	445	411	3	3	NA	NA
Copper	mg/L	ND	ND	ND	0	3	0.025	0.025
Dissolved Oxygen	mg/L	6.16	9.52	7.99	3	3	NA	NA
Flow Rate	mgd	0.05	0.31	0.16	3	3	NA	NA
Hardness - Total as CaCO3	mg/L	90	120	105	3	3	20	20
Iron	mg/L	0.29	2.69	1.37	3	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	3	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	6.7	7.74	7.12	3	3	NA	NA
Phosphorous	mg/L	ND	0.55	0.24	2	3	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	3	11	25
Temperature	deg F	50.7	79.2	68.9	3	3	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	3	1	1
Uranium	mg/L	ND	ND	ND	0	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.75 Non-Radiological Effluent Data for Surface Water Location L64

Massac Creek (Reference)

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	5	1000	1000
Acetone	ug/L	ND	ND	ND	0	5	1000	1000
Aluminum	mg/L	ND	0.494	0.20	2	5	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	5	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	5	10	10
Chloride	mg/L	9.5	13.5	12.1	5	5	2	2
Chromium	mg/L	ND	ND	ND	0	5	0.025	0.05
Conductivity	umho/c	135	155	144	5	5	NA	NA
Copper	mg/L	ND	0.05	0.02	1	5	0.025	0.05
Dissolved Oxygen	mg/L	4.39	9.75	7.3	5	5	NA	NA
Flow Rate	mgd	0.69	11.7	3.5	5	5	NA	NA
Hardness - Total as CaCO3	mg/L	40	72	54	5	5	20	20
Iron	mg/L	0.488	0.957	0.714	5	5	0.2	0.2
Lead	mg/L	ND	ND	ND	0	5	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	5	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	5	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	5	0.17	0.17
pH	Std Unit	6.9	7.4	7.13	5	5	NA	NA
Phosphorous	mg/L	ND	0.11	0.07	4	5	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	5	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	5	10	24
Temperature	deg F	46.6	80.3	64.7	5	5	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	5	1	1
Uranium	mg/L	ND	ND	ND	0	5	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	5	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.76 Non-Radiological Effluent Data for Surface Water Location L135

Upstream C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	ND	2.2	1.3	1	4	2	2
COD	mg/L	26	39	32.3	4	4	25	25
Conductivity	umho/c	73.1	153	113	4	4	NA	NA
Dissolved Oxygen	mg/L	7.11	9.55	8.28	4	4	NA	NA
Dissolved Solids	mg/L	ND	131	90	3	4	100	50
Flow Rate	mgd	0.26	1.4	0.63	4	4	NA	NA
Iron	mg/L	0.863	2.32	1.32	4	4	0.2	0.2
pH	Std Unit	7.1	7.8	7.5	4	4	NA	NA
Sodium	mg/L	ND	2.46	1.37	1	4	2	2
Sulfate	mg/L	6.1	13.1	8.28	4	4	5	5
Suspended Solids	mg/L	ND	143	45.3	2	4	10	25
Temperature	deg F	54.6	71.5	59.2	4	4	NA	NA
TOC	mg/L	10	18	12.8	4	4	1.2	1.6
Total Solids	mg/L	ND	279	152	3	4	100	100
Uranium	mg/L	0.002	0.018	0.007	4	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Table C.77 Non-Radiological Effluent Data for Surface Water Location L136

At the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	3.4	13.2	7.08	4	4	2	2
COD	mg/L	ND	44	30	3	4	25	25
Conductivity	umho/c	152	306	223	4	4	NA	NA
Dissolved Oxygen	mg/L	3.6	7.77	5.63	4	4	NA	NA
Dissolved Solids	mg/L	137	329	222	4	4	48	100
Flow Rate	mgd	0.02	0.58	0.22	4	4	NA	NA
Iron	mg/L	ND	0.367	0.23	3	4	0.2	0.2
pH	Std Unit	7.3	7.7	7.59	4	4	NA	NA
Sodium	mg/L	ND	7.38	3.08	2	4	2	2
Sulfate	mg/L	7.2	83.9	37.7	4	4	5	5
Suspended Solids	mg/L	ND	ND	ND	0	4	10	25
Temperature	deg F	54.6	73	61.3	4	4	NA	NA
TOC	mg/L	9.5	18	13.9	4	4	1.2	1.6
Total Solids	mg/L	143	315	222	4	4	100	100
Uranium	mg/L	ND	0.004	0.002	2	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.78 Non-Radiological Effluent Data for Surface Water Location L137

Downstream of the C-746 S&T Closed Landfills

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	ND	2.8	1.9	2	4	2	2
COD	mg/L	ND	36	24	2	4	25	25
Conductivity	umho/c	73.3	164	124	4	4	NA	NA
Dissolved Oxygen	mg/L	8.02	10.7	8.8	4	4	NA	NA
Dissolved Solids	mg/L	ND	119	99.2	3	4	100	67
Flow Rate	mgd	0.02	1.3	0.48	4	4	NA	NA
Iron	mg/L	1.1	1.76	1.38	4	4	0.2	0.2
pH	Std Unit	7.45	7.8	7.7	4	4	NA	NA
Sodium	mg/L	ND	ND	ND	0	4	2	2
Sulfate	mg/L	6.5	14	10.3	4	4	5	5
Suspended Solids	mg/L	ND	45	27	2	4	10	33
Temperature	deg F	53.3	61.9	56.3	4	4	NA	NA
TOC	mg/L	9.6	15	11.9	4	4	1.2	1.6
Total Solids	mg/L	106	151	135	4	4	100	100
Uranium	mg/L	ND	0.01	0.005	3	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Table C.79 Non-Radiological Effluent Data for Surface Water Location L150

At the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	3.4	5.7	4.63	4	4	2	2
COD	mg/L	ND	56	23.4	1	4	25	25
Conductivity	umho/c	148	324	233	4	4	NA	NA
Dissolved Oxygen	mg/L	5.49	8.4	6.76	4	4	NA	NA
Dissolved Solids	mg/L	123	252	181	4	4	43	100
Flow Rate	mgd	0.074	0.67	0.26	4	4	NA	NA
Iron	mg/L	0.469	0.904	0.623	4	4	0.2	0.2
pH	Std Unit	7.3	7.96	7.68	4	4	NA	NA
Sodium	mg/L	ND	4.63	3.14	3	4	2	2
Sulfate	mg/L	8.1	74.9	40.8	4	4	5	5
Suspended Solids	mg/L	ND	25	12.5	1	4	10	25
Temperature	deg F	53	76.9	60.1	4	4	NA	NA
TOC	mg/L	5.4	22	10.85	4	4	1.2	1.6
Total Solids	mg/L	112	269	203	4	4	100	100
Uranium	mg/L	ND	0.002	0.001	2	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.80 Non-Radiological Effluent Data for Surface Water Location L154

Upstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	ND	2.3	1.9	3	4	2	2
COD	mg/L	ND	37	29	3	4	25	25
Conductivity	umho/c	68.5	149	112	4	4	NA	NA
Dissolved Oxygen	mg/L	6.37	8.21	7.44	4	4	NA	NA
Dissolved Solids	mg/L	ND	137	101	3	4	100	50
Flow Rate	mgd	0.03	0.63	0.299	4	4	NA	NA
Iron	mg/L	0.791	3.15	1.55	4	4	0.2	0.2
pH	Std Unit	7	7.79	7.47	4	4	NA	NA
Sodium	mg/L	ND	ND	ND	0	4	2	2
Sulfate	mg/L	6	12.9	8.8	4	4	5	5
Suspended Solids	mg/L	ND	31	23	3	4	10	25
Temperature	deg F	53.8	71.9	59.1	4	4	NA	NA
TOC	mg/L	8	17	11.6	4	4	1.2	1.6
Total Solids	mg/L	ND	181	122	3	4	100	100
Uranium	mg/L	0.001	0.005	0.003	4	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Table C.81 Non-Radiological Effluent Data for Surface Water Location L155

Downstream of the C-746 U Landfill

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Chloride	mg/L	ND	16.8	6.68	3	4	2	2
COD	mg/L	ND	ND	ND	0	4	25	25
Conductivity	umho/c	53.7	223	135	4	4	NA	NA
Dissolved Oxygen	mg/L	6.59	10.2	8.2	4	4	NA	NA
Dissolved Solids	mg/L	ND	200	122	3	4	200	200
Flow Rate	mgd	0.96	155	52	3	3	NA	NA
Iron	mg/L	1.09	14.9	5.44	4	4	0.2	0.2
pH	Std Unit	7.1	7.81	7.60	4	4	NA	NA
Sodium	mg/L	ND	20.3	7.3	2	4	2	2
Sulfate	mg/L	6.5	34.8	19.2	4	4	5	5
Suspended Solids	mg/L	ND	1390	521	2	4	10	25
Temperature	deg F	55	71.2	59.5	4	4	NA	NA
TOC	mg/L	ND	9.3	6.0	3	4	1.2	1.6
Total Solids	mg/L	115	1570	607	4	4	100	100
Uranium	mg/L	0.006	0.02	0.012	4	4	0.001	0.001

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.82 Non-Radiological Effluent Data for Surface Water Location L194

Little Bayou Creek Downstream of Outfall K010

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	3	1000	1000
Acetone	ug/L	ND	ND	ND	0	3	1000	1000
Aluminum	mg/L	0.351	1.9	0.938	3	3	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	3	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	3	10	10
Chloride	mg/L	21.5	37.1	27.9	3	3	2	2
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.025
Conductivity	umho/c	274	450	341	3	3	NA	NA
Copper	mg/L	ND	ND	ND	0	3	0.025	0.025
Dissolved Oxygen	mg/L	6.8	9.66	7.78	3	3	NA	NA
Flow Rate	mgd	0.26	1.43	0.90	3	3	NA	NA
Hardness - Total as CaCO3	mg/L	68	113	88	3	3	20	20
Iron	mg/L	0.446	1.55	0.857	3	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	3	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	7.3	7.71	7.45	3	3	NA	NA
Phosphorous	mg/L	0.25	0.32	0.293	3	3	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Suspended Solids	mg/L	ND	38	23	2	3	11	24
Temperature	deg F	61.3	87.8	75.6	3	3	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	3	1	1
Uranium	mg/L	0.006	0.027	0.017	3	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable

ND = Non Detect

Table C.83 Non-Radiological Effluent Data for Surface Water Location L241

Downstream Little Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Conductivity	umho/c	160	297	245	4	4	NA	NA
Dissolved Oxygen	mg/L	7.19	11.4	9.55	4	4	NA	NA
Flow Rate	mgd	2.02	4.75	2.8	4	4	NA	NA
pH	Std Unit	7.11	8	7.40	4	4	NA	NA
Temperature	deg F	44.2	79.6	59.4	4	4	NA	NA
Trichloroethene	ug/L	5	30	11.8	4	4	1	1

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.84 Non-Radiological Effluent Data for Surface Water Location L291

Upstream of Plant Effluents Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	3	1000	1000
Acetone	ug/L	ND	ND	ND	0	3	1000	1000
Aluminum	mg/L	ND	0.534	0.35	2	3	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	3	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	3	10	10
Chloride	mg/L	10.2	13	11.6	3	3	2	2
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.025
Conductivity	umho/c	215	269	234	3	3	NA	NA
Copper	mg/L	ND	ND	ND	0	3	0.025	0.025
Dissolved Oxygen	mg/L	3.22	8.15	6.20	3	3	NA	NA
Flow Rate	mgd	0.59	0.91	0.7	3	3	NA	NA
Hardness - Total as CaCO3	mg/L	65	88	74	3	3	20	20
Iron	mg/L	0.224	0.592	0.402	3	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	3	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	7.2	7.69	7.46	3	3	NA	NA
Phosphorous	mg/L	0.05	0.15	0.093	3	3	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	3	11	25
Temperature	deg F	44.4	78.2	65.3	3	3	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	3	1	1
Uranium	mg/L	ND	ND	ND	0	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.85 Non-Radiological Effluent Data for Surface Water Location L306

Cairo Intake Ohio River

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	4	1000	1000
Acetone	ug/L	ND	ND	ND	0	4	1000	1000
Aluminum	mg/L	0.513	0.849	0.661	4	4	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	4	0.01	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	4	10	10
Chloride	mg/L	18.7	27.1	21.1	4	4	2	2
Chromium	mg/L	ND	ND	ND	0	4	0.025	0.05
Conductivity	umho/c	308	354	329	5	5	NA	NA
Copper	mg/L	ND	ND	ND	0	4	0.025	0.05
Dissolved Oxygen	mg/L	6.4	14.4	9.75	5	5	NA	NA
Hardness - Total as CaCO3	mg/L	127	165	152	4	4	20	20
Iron	mg/L	0.582	0.911	0.743	4	4	0.2	0.2
Lead	mg/L	ND	ND	ND	0	4	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	4	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	4	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	4	0.17	0.17
pH	Std Unit	7.5	8.1	7.8	5	5	NA	NA
Phosphorous	mg/L	0.05	0.11	0.08	4	4	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	4	0.17	0.17
Suspended Solids	mg/L	ND	214	67	3	4	10	50
Temperature	deg F	38.7	84.1	63.3	5	5	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	4	1	1
Uranium	mg/L	ND	ND	ND	0	4	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	4	0.2	0.2

NA = Not Applicable

ND = Non Detect

Surface Water Non-Radiological Data

Table C.86 Non-Radiological Effluent Data for Surface Water Location C746K-5

Bayou Creek

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
2-Propanol	ug/L	ND	ND	ND	0	3	1000	1000
Acetone	ug/L	ND	ND	ND	0	3	1000	1000
Aluminum	mg/L	ND	0.33	0.25	2	3	0.2	0.2
Cadmium	mg/L	ND	ND	ND	0	3	0.02	0.02
Carbonaceous BOD	mg/L	ND	ND	ND	0	3	10	10
Chloride	mg/L	9.7	16.8	13.8	3	3	2	2
Chromium	mg/L	ND	ND	ND	0	3	0.025	0.025
Conductivity	umho/c	227	249	241	3	3	NA	NA
Copper	mg/L	ND	0.053	0.026	1	3	0.025	0.025
Dissolved Oxygen	mg/L	4.61	9.98	8.2	3	3	NA	NA
Flow Rate	mgd	0.67	1.53	0.97	3	3	NA	NA
Hardness - Total as CaCO3	mg/L	72	81	77	3	3	20	20
Iron	mg/L	ND	0.918	0.531	2	3	0.2	0.2
Lead	mg/L	ND	ND	ND	0	3	0.2	0.2
Nickel	mg/L	ND	ND	ND	0	3	0.025	0.05
PCB-1016	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1221	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1232	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1242	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1248	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1254	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1260	ug/L	ND	ND	ND	0	3	0.17	0.17
PCB-1268	ug/L	ND	ND	ND	0	3	0.17	0.17
pH	Std Unit	7.3	7.78	7.60	3	3	NA	NA
Phosphorous	mg/L	0.05	0.1	0.07	3	3	0.05	0.05
Polychlorinated biphenyl	ug/L	ND	ND	ND	0	3	0.17	0.17
Suspended Solids	mg/L	ND	ND	ND	0	3	11	25
Temperature	deg F	43.5	80.2	65.9	3	3	NA	NA
Trichloroethene	ug/L	ND	ND	ND	0	3	1	1
Uranium	mg/L	ND	ND	ND	0	3	0.001	0.001
Zinc	mg/L	ND	ND	ND	0	3	0.2	0.2

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.87 Non-Radiological Data for Sediment Location S1

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	3740	5350	4550	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	16.6	19.7	18.2	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	469	656	563	2	2	100	100
Chromium	mg/kg	8.81	26.4	17.6	2	2	2	2.5
Cobalt	mg/kg	ND	ND	ND	0	2	2.5	2.5
Copper	mg/kg	5.62	6.33	5.98	2	2	2	2.5
Iron	mg/kg	6260	7710	6990	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	307	331	319	2	2	15	15
Manganese	mg/kg	71.4	156	114	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	26.7	36.7	31.7	2	2	NA	NA
Nickel	mg/kg	ND	6.27	4.39	1	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2	100	100
Potassium	mg/kg	200	210	205	2	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	200
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	ug/g	ND	8.2	5.35	1	2	0.56	5
Vanadium	mg/kg	12.5	17.9	15.2	2	2	2	2.5
Zinc	mg/kg	22.3	23.6	23.0	2	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.88 Non-Radiological Data for Sediment Location S2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	1490	5120	3310	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	11.3	35.5	23.4	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	189	671	430	2	2	100	100
Chromium	mg/kg	7.82	18.9	13.4	2	2	2	2.5
Cobalt	mg/kg	ND	2.6	2.0	1	2	2.5	2.5
Copper	mg/kg	3.26	8.18	5.72	2	2	2	2.5
Iron	mg/kg	3780	7230	5510	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	112	425	269	2	2	15	15
Manganese	mg/kg	68	113	91	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	28.1	30.5	29.3	2	2	NA	NA
Nickel	mg/kg	ND	5.13	3.82	1	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	200	125	1	2	100	100
PCB-1248	ug/kg	100	100	100	2	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	100	300	200	2	2	100	100
Potassium	mg/kg	ND	248	174	1	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	300
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	ug/g	1.31	5.5	3.41	2	2	0.56	5
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Vanadium	mg/kg	9.31	18.3	13.8	2	2	2	2.5
Zinc	mg/kg	ND	23.2	16.6	1	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.89 Non-Radiological Data for Sediment Location S20

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	874	1500	1190	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	8.3	5.4	1	2	5	5
Barium	mg/kg	9.31	76.8	43.1	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	179	800	490	2	2	100	100
Chromium	mg/kg	5.72	18.9	12.3	2	2	2	2.5
Cobalt	mg/kg	ND	6.79	4.02	1	2	2.5	2.5
Copper	mg/kg	3.4	3.52	3.46	2	2	2	2.5
Iron	mg/kg	3250	9800	6530	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	75.2	161	118.1	2	2	15	15
Manganese	mg/kg	140	679	410	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	19.1	30.4	24.8	2	2	NA	NA
Nickel	mg/kg	ND	ND	ND	0	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2	100	100
Potassium	mg/kg	ND	ND	ND	0	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	200
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	ug/g	ND	ND	ND	0	2	0.56	5
Vanadium	mg/kg	7.95	23.8	15.9	2	2	2	2.5
Zinc	mg/kg	ND	ND	ND	0	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.90 Non-Radiological Data for Sediment Location S21

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	4650	6640	5690	3	3	20	20
Antimony	mg/kg	ND	ND	ND	0	3	20	20
Arsenic	mg/kg	ND	ND	ND	0	3	5	5
Barium	mg/kg	40.2	53.6	46.8	3	3	5	5
Beryllium	mg/kg	ND	0.581	0.36	1	3	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	3	2	2
Calcium	mg/kg	569	1490	907	3	3	100	100
Chromium	mg/kg	12.8	16.9	15	3	3	2	2.5
Cobalt	mg/kg	3.99	4.88	4.51	3	3	2.5	2.5
Copper	mg/kg	4.29	7.67	6.09	3	3	2	2.5
Iron	mg/kg	9970	12700	11800	3	3	10	20
Lead	mg/kg	ND	ND	ND	0	3	20	20
Magnesium	mg/kg	438	614	551	3	3	15	15
Manganese	mg/kg	155	258	206	3	3	10	10
Mercury	mg/kg	ND	ND	ND	0	3	0.2	0.2
Moisture	%	28.6	40.7	34.1	3	3	NA	NA
Nickel	mg/kg	6.9	7.46	7.12	3	3	5	5
PCB-1016	ug/kg	ND	ND	ND	0	3	100	100
PCB-1221	ug/kg	ND	ND	ND	0	3	100	100
PCB-1232	ug/kg	ND	ND	ND	0	3	100	100
PCB-1242	ug/kg	ND	ND	ND	0	3	100	100
PCB-1248	ug/kg	ND	ND	ND	0	3	100	100
PCB-1254	ug/kg	ND	ND	ND	0	3	100	100
PCB-1260	ug/kg	ND	ND	ND	0	3	100	100
PCB-1268	ug/kg	ND	ND	ND	0	3	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	3	100	100
Potassium	mg/kg	ND	301	208	2	3	200	200
Silver	mg/kg	ND	ND	ND	0	3	4	4
Sodium	mg/kg	ND	ND	ND	0	3	200	300
Thallium	mg/kg	ND	ND	ND	0	3	20	20
Uranium	mg/L	ND	ND	ND	0	1	0.56	0.56
Uranium	ug/g	ND	ND	ND	0	2	5	5
Uranium	mg/kg	ND	ND	ND	0	3	200	200
Vanadium	mg/kg	19	28.5	24.1	3	3	2	2.5
Zinc	mg/kg	ND	ND	ND	0	3	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.91 Non-Radiological Data for Sediment Location S27

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	1660	2040	1900	3	3	20	20
Antimony	mg/kg	ND	ND	ND	0	3	20	20
Arsenic	mg/kg	ND	5.48	3.50	1	3	5	5
Barium	mg/kg	18	26.9	21.5	3	3	5	5
Beryllium	mg/kg	ND	0.578	0.36	1	3	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	3	2	2
Calcium	mg/kg	266	279	275	3	3	100	100
Chromium	mg/kg	15	173	72.4	3	3	2	2.5
Cobalt	mg/kg	ND	4.53	2.34	1	3	2.5	2.5
Copper	mg/kg	3.58	8.19	5.43	3	3	2	2.5
Iron	mg/kg	3110	15000	7180	3	3	10	20
Lead	mg/kg	ND	ND	ND	0	3	20	20
Magnesium	mg/kg	150	222	187	3	3	15	15
Manganese	mg/kg	60.8	279	135	3	3	10	10
Mercury	mg/kg	ND	ND	ND	0	3	0.2	0.2
Moisture	%	22.5	31.9	26.5	3	3	NA	NA
Nickel	mg/kg	ND	5.2	3.4	1	3	5	5
PCB-1016	ug/kg	ND	ND	ND	0	3	100	100
PCB-1221	ug/kg	ND	ND	ND	0	3	100	100
PCB-1232	ug/kg	ND	ND	ND	0	3	100	100
PCB-1242	ug/kg	ND	ND	ND	0	3	100	100
PCB-1248	ug/kg	ND	ND	ND	0	3	100	100
PCB-1254	ug/kg	ND	ND	ND	0	3	100	100
PCB-1260	ug/kg	ND	ND	ND	0	3	100	100
PCB-1268	ug/kg	ND	ND	ND	0	3	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	3	100	100
Potassium	mg/kg	ND	ND	ND	0	3	200	200
Silver	mg/kg	ND	ND	ND	0	3	4	4
Sodium	mg/kg	ND	ND	ND	0	3	200	200
Thallium	mg/kg	ND	ND	ND	0	3	20	20
Uranium	ug/g	2.8	20.2	8.72	3	3	0.56	5
Uranium	mg/kg	ND	ND	ND	0	3	200	200
Vanadium	mg/kg	7.32	30.1	15.0	3	3	2	2.5
Zinc	mg/kg	ND	46.4	22.1	1	3	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.92 Non-Radiological Data for Sediment Location S28

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	1000	2600	1800	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	8.95	25.8	17.4	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	ND	294	172	1	2	100	100
Chromium	mg/kg	4.81	5.09	4.95	2	2	2	2.5
Cobalt	mg/kg	ND	2.61	1.93	1	2	2.5	2.5
Copper	mg/kg	ND	9.72	5.49	1	2	2.5	2.5
Iron	mg/kg	3720	4080	3900	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	62.4	294	178	2	2	15	15
Manganese	mg/kg	83.8	138	111	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	20.8	31.2	26	2	2	NA	NA
Nickel	mg/kg	ND	ND	ND	0	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2	100	100
Potassium	mg/kg	ND	ND	ND	0	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	300
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	mg/L	ND	ND	ND	0	1	0.56	0.56
Uranium	ug/g	ND	ND	ND	0	1	5	5
Vanadium	mg/kg	7.99	8.51	8.25	2	2	2	2.5
Zinc	mg/kg	ND	ND	ND	0	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.93 Non-Radiological Data for Sediment Location S30

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	6720	7620	7170	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	11.2	6.9	1	2	5	5
Barium	mg/kg	40.5	57.1	48.8	2	2	5	5
Beryllium	mg/kg	ND	0.534	0.392	1	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	1150	1150	1150	2	2	100	100
Chromium	mg/kg	15.7	17.7	16.7	2	2	2	2.5
Cobalt	mg/kg	5.16	7.76	6.46	2	2	2.5	2.5
Copper	mg/kg	5.87	10.3	8.09	2	2	2	2.5
Iron	mg/kg	11700	11700	11700	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	558	597	578	2	2	15	15
Manganese	mg/kg	225	287	256	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	26.4	33.5	30.0	2	2	NA	NA
Nickel	mg/kg	6.74	7.47	7.12	2	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	200	125	1	2	100	100
PCB-1248	ug/kg	ND	400	225	1	2	100	100
PCB-1254	ug/kg	ND	200	125	1	2	100	100
PCB-1260	ug/kg	ND	200	125	1	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	200	800	500	2	2	100	100
Potassium	mg/kg	242	254	248	2	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	300
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	ug/g	ND	55.8	29.2	1	2	0.56	5
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Vanadium	mg/kg	23.4	25.3	24.4	2	2	2	2.5
Zinc	mg/kg	24.9	28.5	26.7	2	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.94 Non-Radiological Data for Sediment Location S31

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	2580	3680	3130	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	17.4	25.6	21.5	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	847	1620	1230	2	2	100	100
Chromium	mg/kg	6.99	9.35	8.17	2	2	2	2.5
Cobalt	mg/kg	ND	ND	ND	0	2	2.5	2.5
Copper	mg/kg	6.99	10.7	8.85	2	2	2	2.5
Iron	mg/kg	4480	4750	4620	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	307	574	441	2	2	15	15
Manganese	mg/kg	108	109	109	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	30.3	45.5	37.9	2	2	NA	NA
Nickel	mg/kg	ND	6.99	4.75	1	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	300	175	1	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	300	175	1	2	100	100
Potassium	mg/kg	ND	208	154	1	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	200
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	ug/g	3.91	7.7	5.81	2	2	0.56	5
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Vanadium	mg/kg	10.5	10.5	10.5	2	2	2	2.5
Zinc	mg/kg	21.1	41.1	31.1	2	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.95 Non-Radiological Data for Sediment Location S32

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	8630	10500	9570	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	5.29	3.9	1	2	5	5
Barium	mg/kg	49.3	61.9	55.6	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	2360	2620	2490	2	2	100	100
Chromium	mg/kg	30.2	104	67.1	2	2	2	2.5
Cobalt	mg/kg	3.78	4.25	4.02	2	2	2.5	2.5
Copper	mg/kg	16.2	80.8	48.5	2	2	2	2.5
Iron	mg/kg	9260	11500	10400	2	2	10	20
Lead	mg/kg	ND	23.4	16.7	1	2	20	20
Magnesium	mg/kg	836	1100	968	2	2	15	15
Manganese	mg/kg	190	237	214	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	41.1	45.9	43.5	2	2	NA	NA
Nickel	mg/kg	29.8	41.6	35.7	2	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	200	125	1	2	100	100
PCB-1248	ug/kg	ND	700	375	1	2	100	100
PCB-1254	ug/kg	200	500	350	2	2	100	100
PCB-1260	ug/kg	ND	500	275	1	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	400	1700	1050	2	2	100	100
Potassium	mg/kg	674	766	720	2	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	300
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	ug/g	23.9	58.5	41.2	2	2	0.56	5
Vanadium	mg/kg	24.4	24.6	24.5	2	2	2	2.5
Zinc	mg/kg	46.6	113	79.8	2	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.96 Non-Radiological Data for Sediment Location S33

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	670	2830	1750	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	ND	27	15	1	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	ND	351	201	1	2	100	100
Chromium	mg/kg	8.24	10.5	9.37	2	2	2	2.5
Cobalt	mg/kg	ND	2.75	2	1	2	2.5	2.5
Copper	mg/kg	ND	4.84	3.05	1	2	2.5	2.5
Iron	mg/kg	3240	7230	5240	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	40.6	288	164	2	2	15	15
Manganese	mg/kg	47.7	108	77.9	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	24.2	38.4	31.3	2	2	NA	NA
Nickel	mg/kg	ND	ND	ND	0	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2	100	100
Potassium	mg/kg	ND	ND	ND	0	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	200
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	ug/g	ND	5	2.8	1	2	0.56	5
Vanadium	mg/kg	7.8	10.6	9.2	2	2	2	2.5
Zinc	mg/kg	ND	20.2	15.1	1	2	20	20

NA = Not Applicable

ND = Non Detect

Sediment Non-Radiological Data

Table C.97 Non-Radiological Data for Sediment Location S34

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Limits	Maximum of Detection Limits
Aluminum	mg/kg	1440	4540	2990	2	2	20	20
Antimony	mg/kg	ND	ND	ND	0	2	20	20
Arsenic	mg/kg	ND	ND	ND	0	2	5	5
Barium	mg/kg	12	23.3	17.7	2	2	5	5
Beryllium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Cadmium	mg/kg	ND	ND	ND	0	2	2	2
Calcium	mg/kg	162	422	292	2	2	100	100
Chromium	mg/kg	22.1	73	47.6	2	2	2	2.5
Cobalt	mg/kg	2.83	3	2.9	2	2	2.5	2.5
Copper	mg/kg	4.2	5.41	4.81	2	2	2	2.5
Iron	mg/kg	7440	10100	8770	2	2	10	20
Lead	mg/kg	ND	ND	ND	0	2	20	20
Magnesium	mg/kg	79.6	265	172	2	2	15	15
Manganese	mg/kg	76.6	79.3	78.0	2	2	10	10
Mercury	mg/kg	ND	ND	ND	0	2	0.2	0.2
Moisture	%	21.8	25.6	23.7	2	2	NA	NA
Nickel	mg/kg	ND	ND	ND	0	2	5	5
PCB-1016	ug/kg	ND	ND	ND	0	2	100	100
PCB-1221	ug/kg	ND	ND	ND	0	2	100	100
PCB-1232	ug/kg	ND	ND	ND	0	2	100	100
PCB-1242	ug/kg	ND	ND	ND	0	2	100	100
PCB-1248	ug/kg	ND	ND	ND	0	2	100	100
PCB-1254	ug/kg	ND	ND	ND	0	2	100	100
PCB-1260	ug/kg	ND	ND	ND	0	2	100	100
PCB-1268	ug/kg	ND	ND	ND	0	2	100	100
Polychlorinated biphenyl	ug/kg	ND	ND	ND	0	2	100	100
Potassium	mg/kg	ND	231	166	1	2	200	200
Silver	mg/kg	ND	ND	ND	0	2	4	4
Sodium	mg/kg	ND	ND	ND	0	2	200	200
Thallium	mg/kg	ND	ND	ND	0	2	20	20
Uranium	mg/kg	ND	ND	ND	0	2	200	200
Uranium	ug/g	ND	5	3.7	1	2	0.56	5
Vanadium	mg/kg	14.5	24.7	19.6	2	2	2	2.5
Zinc	mg/kg	ND	ND	ND	0	2	20	20

NA = Not Applicable

ND = Non Detect

Deer Non-Radiological Data

Table C.98 Non-Radiological Analysis of Deer Muscle Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	ND	1.69	0.72	1	9	1.22	1.22
Antimony	mg/kg	ND	1.08	0.60	3	9	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	9	0.14	0.15
Barium	mg/kg	ND	0.058	2.28	3	9	0.017	0.017
Beryllium	mg/kg	ND	ND	ND	0	9	0.008	0.008
Cadmium	mg/kg	ND	0.12	0.053	3	9	0.064	0.064
Chromium	mg/kg	ND	ND	ND	0	9	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	9	0.234	0.234
Copper	mg/kg	1.15	2.02	1.60	9	9	0.153	0.153
Iron	mg/kg	25.5	42.1	34.4	9	9	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	9	0.805	0.805
Manganese	mg/kg	0.098	0.811	0.22	9	9	0.017	0.019
Mercury	mg/kg	ND	ND	ND	0	9	0.023	0.025
Nickel	mg/kg	ND	ND	ND	0	9	0.303	0.303
Selenium	mg/kg	ND	ND	ND	0	9	0.24	0.25
Silver	mg/kg	ND	ND	ND	0	9	0.098	0.098
Thallium	mg/kg	ND	ND	ND	0	9	0.875	0.875
Vanadium	mg/kg	ND	ND	ND	0	9	0.125	0.125
Zinc	mg/kg	11.1	19.4	14.7	9	9	0.073	0.073

NA = Not Applicable

ND = Non Detect

Table C.99 Non-Radiological Background (BWMA) Analysis of Deer Muscle Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	ND	ND	ND	0	2	1.22	1.22
Antimony	mg/kg	ND	ND	ND	0	2	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	2	0.15	0.15
Barium	mg/kg	ND	0.0369	0.023	1	2	0.017	0.017
Beryllium	mg/kg	ND	0.00847	0.00632	1	2	0.008	0.008
Cadmium	mg/kg	ND	ND	ND	0	2	0.064	0.064
Chromium	mg/kg	ND	ND	ND	0	2	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	2	0.234	0.234
Copper	mg/kg	1.36	1.78	1.57	2	2	0.153	0.153
Iron	mg/kg	41.6	53.3	47.5	2	2	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	2	0.805	0.805
Manganese	mg/kg	0.126	0.241	0.184	2	2	0.017	0.019
Mercury	mg/kg	ND	ND	ND	0	2	0.02	0.024
Nickel	mg/kg	ND	ND	ND	0	2	0.303	0.303
Selenium	mg/kg	ND	ND	ND	0	2	0.24	0.25
Silver	mg/kg	ND	0.151	0.10	1	2	0.098	0.098
Thallium	mg/kg	ND	ND	ND	0	2	0.875	0.875
Vanadium	mg/kg	ND	ND	ND	0	2	0.125	0.125
Zinc	mg/kg	13.2	17.1	15.2	2	2	0.073	0.073

NA = Not Applicable

ND = Non Detect

Deer Non-Radiological Data

Table C.100 Non-Radiological Analysis of Deer Liver Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	ND	2.83	1.61	7	9	1.22	1.22
Antimony	mg/kg	ND	ND	ND	0	9	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	9	0.14	0.15
Barium	mg/kg	ND	0.145	0.050	7	9	0.017	0.017
Beryllium	mg/kg	ND	ND	ND	0	9	0.008	0.008
Cadmium	mg/kg	ND	0.331	0.13	7	9	0.064	0.064
Chromium	mg/kg	ND	0.367	0.20	1	9	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	9	0.234	0.234
Copper	mg/kg	13.1	95	51.9	9	9	0.153	0.153
Iron	mg/kg	73.2	207	103	9	9	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	9	0.805	0.805
Lipids	%	5.1	6.41	5.89	9	9	0.5	0.5
Manganese	mg/kg	3.19	5.47	4.31	9	9	0.017	0.017
Mercury	mg/kg	ND	ND	ND	0	9	0.018	0.025
Nickel	mg/kg	ND	1.47	0.55	6	9	0.303	0.303
PCB-1016	ug/kg	ND	ND	ND	0	9	9.8	10
PCB-1221	ug/kg	ND	ND	ND	0	9	19.6	20
PCB-1232	ug/kg	ND	ND	ND	0	9	9.8	10
PCB-1242	ug/kg	ND	ND	ND	0	9	9.8	10
PCB-1248	ug/kg	ND	ND	ND	0	9	9.8	10
PCB-1254	ug/kg	ND	ND	ND	0	9	9.8	10
PCB-1260	ug/kg	ND	ND	ND	0	9	9.8	10
Selenium	mg/kg	ND	0.25	0.14	1	9	0.24	0.25
Silver	mg/kg	ND	6.47	0.76	1	9	0.098	0.098
Thallium	mg/kg	ND	0.975	0.486	1	9	0.875	0.875
Vanadium	mg/kg	ND	ND	ND	0	9	0.125	0.125
Zinc	mg/kg	25.8	42.6	37.2	9	9	0.073	0.073

NA = Not Applicable

ND = Non Detect

Deer Non-Radiological Data

Table C.101 Non-Radiological Background (BWMA) Analysis of Deer Liver Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	ND	1.24	0.92	1	2	1.22	1.22
Antimony	mg/kg	ND	ND	ND	0	2	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	2	0.15	0.15
Barium	mg/kg	ND	0.025	0.017	1	2	0.017	0.017
Beryllium	mg/kg	ND	ND	ND	0	2	0.008	0.008
Cadmium	mg/kg	0.142	0.335	0.239	2	2	0.064	0.064
Chromium	mg/kg	ND	ND	ND	0	2	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	2	0.234	0.234
Copper	mg/kg	25.2	42.1	33.7	2	2	0.153	0.153
Iron	mg/kg	125	194	159.5	2	2	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	2	0.805	0.805
Lipids	%	4.86	5.23	5.05	2	2	0.5	0.5
Manganese	mg/kg	3.23	3.54	3.39	2	2	0.017	0.017
Mercury	mg/kg	ND	ND	ND	0	2	0.023	0.024
Nickel	mg/kg	ND	0.432	0.29	1	2	0.303	0.303
PCB-1016	ug/kg	ND	ND	ND	0	2	9.5	9.95
PCB-1221	ug/kg	ND	ND	ND	0	2	19.9	19.9
PCB-1232	ug/kg	ND	ND	ND	0	2	9.5	9.95
PCB-1242	ug/kg	ND	ND	ND	0	2	9.5	9.95
PCB-1248	ug/kg	ND	ND	ND	0	2	9.5	9.95
PCB-1254	ug/kg	ND	ND	ND	0	2	9.5	9.95
PCB-1260	ug/kg	ND	ND	ND	0	2	9.5	9.95
Selenium	mg/kg	ND	ND	ND	0	2	0.25	0.25
Silver	mg/kg	ND	ND	ND	0	2	0.098	0.098
Thallium	mg/kg	ND	ND	ND	0	2	0.875	0.875
Vanadium	mg/kg	ND	ND	ND	0	2	0.125	0.125
Zinc	mg/kg	33.4	37.7	35.6	2	2	0.073	0.073

NA = Not Applicable

ND = Non Detect

Table C.102 Non-Radiological Analysis of Deer Fat Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	35.4	78.7	54.4	6	6	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	6	9.8	10
PCB-1221	ug/kg	ND	ND	ND	0	6	19.6	20
PCB-1232	ug/kg	ND	ND	ND	0	6	9.8	10
PCB-1242	ug/kg	ND	ND	ND	0	6	9.8	10
PCB-1248	ug/kg	ND	ND	ND	0	6	9.8	10
PCB-1254	ug/kg	ND	ND	ND	0	6	9.8	10
PCB-1260	ug/kg	25.3	146	64	6	6	9.8	10

NA = Not Applicable

ND = Non Detect

Deer Non-Radiological Data

Table C.103 Non-Radiological Background (BWMA) Analysis of Deer Fat Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	53.8	87.7	70.8	2	2	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	2	9.8	9.85
PCB-1221	ug/kg	ND	ND	ND	0	2	19.6	19.7
PCB-1232	ug/kg	ND	ND	ND	0	2	9.8	9.85
PCB-1242	ug/kg	ND	ND	ND	0	2	9.8	9.85
PCB-1248	ug/kg	ND	ND	ND	0	2	9.8	9.85
PCB-1254	ug/kg	ND	ND	ND	0	2	9.8	9.85
PCB-1260	ug/kg	ND	23.8	14.4	1	2	9.8	9.85

NA = Not Applicable

ND = Non Detect

Table C.104 Non-Radiological Analysis of Deer Kidney Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	ND	ND	ND	0	9	1.22	1.22
Antimony	mg/kg	ND	ND	ND	0	9	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	9	0.14	0.15
Barium	mg/kg	0.251	0.627	0.415	9	9	0.017	0.017
Beryllium	mg/kg	ND	ND	ND	0	9	0.008	0.008
Cadmium	mg/kg	0.275	3.88	1.44	9	9	0.064	0.064
Chromium	mg/kg	ND	ND	ND	0	9	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	9	0.234	0.234
Copper	mg/kg	3.83	5.31	4.47	9	9	0.153	0.153
Iron	mg/kg	48.3	79.9	61.2	9	9	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	9	0.805	0.805
Manganese	mg/kg	1.45	2.03	1.66	9	9	0.017	0.019
Mercury	mg/kg	ND	0.072	0.023	3	9	0.024	0.025
Nickel	mg/kg	ND	ND	ND	0	9	0.303	0.303
Selenium	mg/kg	0.79	1.3	1.00	9	9	0.24	0.25
Silver	mg/kg	ND	0.129	0.0688	3	9	0.098	0.098
Thallium	mg/kg	ND	ND	ND	0	9	0.875	0.875
Vanadium	mg/kg	ND	0.14	0.070	1	9	0.125	0.125
Zinc	mg/kg	23.2	33.3	28.6	9	9	0.073	0.073

NA = Not Applicable

ND = Non Detect

Deer Non-Radiological Data

Table C.105 Non-Radiological Background (BWMA) Analysis of Deer Kidney Tissue for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	1.22	2.12	1.67	2	2	1.22	1.22
Antimony	mg/kg	ND	ND	ND	0	2	0.84	0.84
Arsenic	mg/kg	ND	ND	ND	0	2	0.15	0.15
Barium	mg/kg	0.202	0.445	0.32	2	2	0.0169	0.0169
Beryllium	mg/kg	ND	ND	ND	0	2	0.00835	0.00835
Cadmium	mg/kg	1.27	3.21	2.24	2	2	0.064	0.064
Chromium	mg/kg	ND	ND	ND	0	2	0.367	0.367
Cobalt	mg/kg	ND	ND	ND	0	2	0.234	0.234
Copper	mg/kg	3.44	3.51	3.475	2	2	0.153	0.153
Iron	mg/kg	96.5	139	118	2	2	0.135	0.135
Lead	mg/kg	ND	ND	ND	0	2	0.805	0.805
Manganese	mg/kg	1.3	3.59	2.45	2	2	0.019	0.019
Mercury	mg/kg	ND	ND	ND	0	2	0.024	0.025
Nickel	mg/kg	ND	ND	ND	0	2	0.303	0.303
Selenium	mg/kg	0.88	1	0.94	2	2	0.25	0.25
Silver	mg/kg	ND	ND	ND	0	2	0.0975	0.0975
Thallium	mg/kg	ND	ND	ND	0	2	0.875	0.875
Vanadium	mg/kg	ND	ND	ND	0	2	0.125	0.125
Zinc	mg/kg	24	28.5	26.25	2	2	0.073	0.073

NA = Not Applicable

ND = Non Detect

Fish Tissue Non-Radiological Data

Table C.106 Non-Radiological Analysis of Fish Tissue for 2000 at Location BBK 10.0

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	1.71	1.71	1.71	1	1	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	1	9.95	9.95
PCB-1221	ug/kg	ND	ND	ND	0	1	19.9	19.9
PCB-1232	ug/kg	ND	ND	ND	0	1	9.95	9.95
PCB-1242	ug/kg	ND	ND	ND	0	1	9.95	9.95
PCB-1248	ug/kg	29	29	29	1	1	9.95	9.95
PCB-1254	ug/kg	ND	ND	ND	0	1	9.95	9.95
PCB-1260	ug/kg	85.4	85.4	85.4	1	1	9.95	9.95

NA = Not Applicable
ND = Non Detect

Table C.107 Non-Radiological Analysis of Fish Tissue for 2000 at Location LUK 4.3

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	0.96	2	1.2	6	6	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1221	ug/kg	ND	ND	ND	0	6	19.9	20
PCB-1232	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1242	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1248	ug/kg	ND	49.2	12.5	1	6	10	10
PCB-1254	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1260	ug/kg	14.5	84.9	34.1	6	6	9.95	10

NA = Not Applicable
ND = Non Detect

Table C.108 Non-Radiological Analysis of Fish Tissue for 2000 at Location LUK 7.2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	0.62	0.82	0.69	6	6	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1221	ug/kg	ND	ND	ND	0	6	19.9	20
PCB-1232	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1242	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1248	ug/kg	46.9	83.4	57.7	6	6	9.95	10
PCB-1254	ug/kg	ND	ND	ND	0	6	9.95	10
PCB-1260	ug/kg	141	727	302	6	6	49.8	400
Uranium	pCi/g	ND	ND	ND	0	1	2.72	2.72

NA = Not Applicable
ND = Non Detect

Fish Tissue Non-Radiological Data

Table C.109 Non-Radiological Analysis of Fish Tissue for 2000 at Location LUK 9.2

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	0.75	1.12	0.93	6	6	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	6	9.9	10
PCB-1221	ug/kg	ND	ND	ND	0	6	19.8	20
PCB-1232	ug/kg	ND	ND	ND	0	6	9.9	10
PCB-1242	ug/kg	ND	ND	ND	0	6	9.9	10
PCB-1248	ug/kg	51.7	112	87.3	6	6	9.9	10
PCB-1254	ug/kg	ND	ND	ND	0	6	9.9	10
PCB-1260	ug/kg	331	938	526	6	6	99.5	200

NA = Not Applicable
ND = Non Detect

Table C.110 Non-Radiological Analysis of Fish Tissue for 2000 at Location MAK 13.8

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Lipids	%	0.71	1.63	0.976	7	7	0.5	0.5
PCB-1016	ug/kg	ND	ND	ND	0	7	9.95	10.7
PCB-1221	ug/kg	ND	ND	ND	0	7	19.9	21.3
PCB-1232	ug/kg	ND	ND	ND	0	7	9.95	10.7
PCB-1242	ug/kg	ND	ND	ND	0	7	9.95	10.7
PCB-1248	ug/kg	ND	18.8	7.03	1	7	9.95	9.95
PCB-1254	ug/kg	ND	ND	ND	0	7	9.95	10.7
PCB-1260	ug/kg	ND	ND	ND	0	7	9.95	10.7

NA = Not Applicable
ND = Non Detect

Drum Mountain Area Non-Radiological Mammal Data

Table C.111 Non-Radiological Analysis of Small Mammal Tissue (Mouse) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	4.36	28.6	16.5	2	2	1.72	1.72
Antimony	mg/kg	ND	ND	ND	0	2	4.08	4.08
Arsenic	mg/kg	ND	ND	ND	0	2	0.3	0.3
Barium	mg/kg	ND	2.98	1.52	1	2	0.14	0.14
Beryllium	mg/kg	ND	ND	ND	0	2	0.02	0.02
Cadmium	mg/kg	ND	ND	ND	0	2	0.23	0.23
Chromium	mg/kg	ND	ND	ND	0	2	1.23	1.23
Cobalt	mg/kg	ND	ND	ND	0	2	1.98	1.98
Copper	mg/kg	3.33	6.79	5.06	2	2	0.34	0.34
Iron	mg/kg	269	458	364	2	2	0.58	0.58
Lead	mg/kg	ND	ND	ND	0	2	2.94	2.94
Lipids	ppm	6.3	6.3	6.3	1	1	0.5	0.5
Manganese	mg/kg	1.71	6.81	4.26	2	2	0.09	0.09
Mercury	mg/kg	ND	ND	ND	0	2	0.025	0.025
Nickel	mg/kg	ND	0.944	0.64	1	2	0.7	0.7
PCB-1016	ug/kg	ND	ND	ND	0	2	49	250
PCB-1221	ug/kg	ND	ND	ND	0	2	99	490
PCB-1232	ug/kg	ND	ND	ND	0	2	49	250
PCB-1242	ug/kg	ND	ND	ND	0	2	49	250
PCB-1248	ug/kg	ND	ND	ND	0	2	49	250
PCB-1254	ug/kg	ND	ND	ND	0	2	49	250
PCB-1260	ug/kg	810	850	830	2	2	49	250
Selenium	mg/kg	ND	ND	ND	0	2	0.49	0.5
Silver	mg/kg	ND	ND	ND	0	2	0.41	0.41
Thallium	mg/kg	ND	ND	ND	0	2	3.91	3.91
Uranium	pCi/g	21.4	23	22.2	2	2	7.12	13.1
Vanadium	mg/kg	ND	0.364	0.24	1	2	0.26	0.26
Zinc	mg/kg	20.6	45.5	33.1	2	2	0.52	0.52

NA = Not Applicable

ND = Non Detect

Drum Mountain Area Non-Radiological Mammal Data

Table C.112 Non-Radiological Analysis of Small Mammal Tissue (Opossum) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	18.2	18.2	18.2	1	1	1.72	1.72
Antimony	mg/kg	ND	ND	ND	0	1	4.08	4.08
Arsenic	mg/kg	ND	ND	ND	0	1	0.3	0.3
Barium	mg/kg	0.232	0.232	0.232	1	1	0.14	0.14
Beryllium	mg/kg	0.019	0.019	0.019	1	1	0.02	0.02
Cadmium	mg/kg	ND	ND	ND	0	1	0.23	0.23
Chromium	mg/kg	ND	ND	ND	0	1	1.23	1.23
Cobalt	mg/kg	ND	ND	ND	0	1	1.98	1.98
Copper	mg/kg	1.67	1.67	1.67	1	1	0.34	0.34
Iron	mg/kg	53.4	53.4	53.4	1	1	0.58	0.58
Lead	mg/kg	ND	ND	ND	0	1	2.94	2.94
Manganese	mg/kg	0.667	0.667	0.667	1	1	0.09	0.09
Mercury	mg/kg	0.047	0.047	0.047	1	1	0.025	0.025
Nickel	mg/kg	1.04	1.04	1.04	1	1	0.7	0.7
Selenium	mg/kg	ND	ND	ND	0	1	0.5	0.5
Silver	mg/kg	ND	ND	ND	0	1	0.41	0.41
Thallium	mg/kg	ND	ND	ND	0	1	3.91	3.91
Uranium	pCi/g	ND	ND	ND	0	2	3.8	4.01
Vanadium	mg/kg	ND	ND	ND	0	1	0.26	0.26
Zinc	mg/kg	53.1	53.1	53.1	1	1	0.52	0.52

NA = Not Applicable

ND = Non Detect

Drum Mountain Area Non-Radiological Mammal Data

Table C.113 Non-Radiological Analysis of Small Mammal Tissue (Raccoon 1) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	2.04	2.54	2.29	2	2	1.72	1.72
Antimony	mg/kg	ND	ND	ND	0	2	4.08	4.08
Arsenic	mg/kg	ND	ND	ND	0	2	0.3	0.3
Barium	mg/kg	ND	ND	ND	0	2	0.14	0.14
Beryllium	mg/kg	ND	ND	ND	0	2	0.02	0.02
Cadmium	mg/kg	ND	0.262	0.187	1	2	0.23	0.23
Chromium	mg/kg	ND	ND	ND	0	2	1.23	1.23
Cobalt	mg/kg	ND	ND	ND	0	2	1.98	1.98
Copper	mg/kg	1.91	10.9	6.41	2	2	0.34	0.34
Iron	mg/kg	48.4	878	463	2	2	0.58	0.58
Lead	mg/kg	ND	ND	ND	0	2	2.94	2.94
Lipids	ppm	2.3	48	25.2	2	2	0.5	0.5
Manganese	mg/kg	0.357	2.39	1.37	2	2	0.09	0.09
Mercury	mg/kg	0.025	0.081	0.053	2	2	0.025	0.025
Nickel	mg/kg	ND	0.75	0.54	1	2	0.7	0.7
PCB-1016	ug/kg	ND	ND	ND	0	3	48	970
PCB-1221	ug/kg	ND	ND	ND	0	3	97	1900
PCB-1232	ug/kg	ND	ND	ND	0	3	48	970
PCB-1242	ug/kg	ND	ND	ND	0	3	48	970
PCB-1248	ug/kg	ND	ND	ND	0	3	48	970
PCB-1254	ug/kg	ND	ND	ND	0	3	48	970
PCB-1260	ug/kg	ND	13000	6000	2	3	48	970
Selenium	mg/kg	ND	0.94	0.59	1	2	0.5	0.5
Silver	mg/kg	ND	ND	ND	0	2	0.41	0.41
Thallium	mg/kg	ND	ND	ND	0	2	3.91	3.91
Vanadium	mg/kg	ND	0.624	0.38	1	2	0.26	0.26
Zinc	mg/kg	41.9	45.3	43.6	2	2	0.52	0.52

NA = Not Applicable

ND = Non Detect

Drum Mountain Area Non-Radiological Mammal Data

Table C.114 Non-Radiological Analysis of Small Mammal Tissue (Raccoon 2) for 2000

Analysis	Units	Minimum	Maximum	Average	Count Detects	Count Samples	Minimum of Detection Detection Limits	Maximum of Detection Detection Limits
Aluminum	mg/kg	2.19	20.5	11.3	2	2	1.72	1.72
Antimony	mg/kg	ND	ND	ND	0	2	4.08	4.08
Arsenic	mg/kg	ND	ND	ND	0	2	0.3	0.3
Barium	mg/kg	ND	ND	ND	0	2	0.14	0.14
Beryllium	mg/kg	ND	ND	ND	0	2	0.02	0.02
Cadmium	mg/kg	ND	0.266	0.188	1	2	0.23	0.23
Chromium	mg/kg	ND	ND	ND	0	2	1.23	1.23
Cobalt	mg/kg	ND	ND	ND	0	2	1.98	1.98
Copper	mg/kg	3.37	4.4	3.89	2	2	0.34	0.34
Iron	mg/kg	71	608	340	2	2	0.58	0.58
Lead	mg/kg	ND	ND	ND	0	2	2.94	2.94
Lipids	ppm	1.3	51	26.2	2	2	0.5	0.5
Manganese	mg/kg	0.444	2.15	1.30	2	2	0.09	0.09
Mercury	mg/kg	0.051	0.508	0.28	2	2	0.025	0.1
Nickel	mg/kg	ND	ND	ND	0	2	0.7	0.7
PCB-1016	ug/kg	ND	ND	ND	0	3	48	480
PCB-1221	ug/kg	ND	ND	ND	0	3	96	960
PCB-1232	ug/kg	ND	ND	ND	0	3	48	480
PCB-1242	ug/kg	ND	ND	ND	0	3	48	480
PCB-1248	ug/kg	ND	ND	ND	0	3	48	480
PCB-1254	ug/kg	ND	ND	ND	0	3	48	480
PCB-1260	ug/kg	ND	4800	2900	2	3	48	50
Selenium	mg/kg	ND	ND	ND	0	2	0.5	0.5
Silver	mg/kg	ND	ND	ND	0	2	0.41	0.41
Thallium	mg/kg	ND	ND	ND	0	2	3.91	3.91
Uranium	pCi/g	ND	ND	ND	0	1	7.04	7.04
Vanadium	mg/kg	ND	0.364	0.245	1	2	0.26	0.26
Zinc	mg/kg	27	60.5	43.8	2	2	0.52	0.52

NA = Not Applicable

ND = Non Detect

Appendix D: Groundwater Contamination Assessment

This appendix contains excerpts from the report, *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2000 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC/PAD-169/R1) issued by Bechtel Jacobs Company LLC in April 2001. The complete document is available through the U.S. Department of Energy Environmental Information Center in Kevil, Kentucky. Most of the information presented in the report is provided here; however, figures and maps are not reproduced in this publication. Where omissions from the original report occur, the text is bolded with an explanation of how to find the omitted information. Where Appendix A and Appendix B are referenced, these are appendices to the original report and are not included in this Annual Site Environmental Report.

The remaining tables of data sets and graphs in the report, *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2000 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* (BJC/PAD-169/R1), are available in the DOE Environmental Information Center.

1. INTRODUCTION

The U.S. Department of Energy's (DOE's) Paducah Gaseous Diffusion Plant (PGDP) has been the subject of intense environmental monitoring over the last decade. Annual DOE reports present a summary of yearly monitoring results. These yearly monitoring results have been incorporated within the database of site-wide investigations, as they occurred. The previous site-wide investigations have included the following:

- *Results of the Site Investigation, Phase I, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991);
- *Results of the Site Investigation, Phase II, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992);
- *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (MMES 1992);
- *Northeast Plume Preliminary Characterization Summary Report, Paducah, Kentucky* (DOE 1995a); and
- *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data* (DOE 1995b).

More recently, the DOE has completed several remedial investigations of known or suspected sources to the main off-site groundwater plumes migrating from the PGDP. The investigation reports include the following:

- *Remedial Investigation Report for the Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999a);
- *Remedial Investigation Report for the Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b);
- *Remedial Investigation Report for the Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000a);
- *Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000b);
- *Site Evaluation Report for Waste Area Grouping 8 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000c); and
- *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000d).

This report is the second of a series of annual interpretations of groundwater data for the PGDP, including revision of the site groundwater plume maps, to assess the extent of trichloroethene (TCE) and technetium-99 (^{99}Tc) in the shallow aquifer for the preceding year. The plume maps include data from the above referenced documents in addition to routine groundwater monitoring data collected through the end of calendar year (CY) 2000. These maps are consistent with interpreted groundwater flow directions determined from hydraulic potential trends of the shallow aquifer and conceptual models of the influence of surface-water bodies. Significant revisions to the 1999 edition of the plume maps are discussed in Sect. 4. These reports provide a basis for timely incorporation of routine groundwater monitoring and characterization data for planned remedial actions.

2. SETTING

The PGDP is located in the Jackson Purchase region of western Kentucky, approximately 16.1 km (10 miles) west of Paducah, Kentucky and 6.5 km (4 miles) south of the Ohio River. Cretaceous marine sediments of the Mississippi Embayment, resting upon a Mississippian-age carbonate bedrock, underlie the PGDP at depth. Buried river deposits of the ancestral Tennessee River unconformably overlie the Cretaceous sediments directly beneath the PGDP. A thick gravel deposit at a general depth of 18.3 m (60 ft) below most of the PGDP forms the shallow aquifer, the Regional Gravel Aquifer (RGA). The RGA is the main conduit for groundwater flow to the north, where groundwater discharges into the Ohio River, and

the main pathway for off-site contaminant plume migration. Fig. 1 **(not shown in this report)** presents a general cross-section of the site geology, while Fig. 2 **(not shown in this report)** illustrates the main features of the groundwater flow systems.

Trichloroethene, a common solvent, and ^{99}Tc, a man-made radioisotope, are the most widespread groundwater contaminants associated with the PGDP. TCE occurs as pure phase (free-product) dense nonaqueous-phase liquid (DNAPL) at multiple locations in the silts and clays overlying the RGA and, most probably, in the RGA itself at some locations. Technetium-99 is a widespread soil contaminant at the PGDP and a common contaminant in many PGDP burial grounds. Both dissolved TCE and ^{99}Tc migrate with downward percolating water to the RGA. In addition, pools of TCE within the RGA are able to yield much higher dissolved levels in groundwater. These contaminants have resulted in large-scale dissolved-phase plumes that are migrating from the PGDP toward the Ohio River. Table 1 presents a summary of the PGDP groundwater plumes.

DOE has taken three discrete actions to contain the groundwater contamination and mitigate the risk to the public that is associated with groundwater. Two separate interim remedial actions installed pump-and-treat systems in the Northwest and Northeast Plumes. Both pump-and-treat systems consist of well fields at the leading edge of the high concentration core of the plumes. The Northwest Plume treatment system also includes a well field near the PGDP security fence. To minimize risks to residents and businesses north of the PGDP, DOE maintains a Water Policy, whereby DOE provides municipal water to area residents and businesses.

3. REVISED PLUME MAPS

A primary component of the annual groundwater report is a revision of the site maps of TCE and ^{99}Tc levels in the RGA. These maps (presented in Appendix A) **(not shown in this report)** represent the contaminant extent during the preceding year based upon (1) analysis of groundwater samples collected during the previous year, (2) temporal trends in groundwater samples collected from monitoring wells, and (3) interpreted contaminant levels based on previous analyses and a conceptual model of contaminant trends. Appendix B **(not shown in this report)** includes plots of contaminant levels over time for trends cited in this report. The attached maps are based on the available TCE and ^{99}Tc analyses of groundwater found in DOE's Oak Ridge Environmental Information System (OREIS) database at the end of CY 2000. These data include records for 132 RGA wells and piezometers and 1279 depth-discrete samples collected from the RGA. The data set (Appendix B - **not shown in this report**) incorporates analyses of the Remedial Investigations (RIs) of Waste Area Groupings (WAGs) 3 (DOE 2000d), 6 (DOE 1999a), 27 (DOE 1999b), and 28 (DOE 2000a), as well as the Sitewide Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination (DOE 2000b) and the Site Evaluation Report for WAG 8 (DOE 2000c).

Maps of TCE and ^{99}Tc are presented at two scales to best present the greater available detail for the PGDP plant and to show the larger off-site area impacted by the PGDP. The plant map (1:4800 scale) covers the 303 hectares (748 acres) contained within the PGDP security fence. Metropolis Lake

Table 1. PGDP groundwater plumes, CY 2000

Plume	Approximate maximum off-site contaminant levels	Off-site plume length
	Trichloroethene	
Northeast	1100 ug/L	3.5 km (2.2 miles)
Northwest	10,000 ug/L	4.6 km (2.8 miles)
Southwest	350 ug/L	0.2 km (0.1 miles)
	Technetium-99	
Northwest	3000 pCi/L	4.1 km (2.5 miles)
Southwest	1670 pCi/L	0.7 km (0.4 miles)
Technetium-99	400 pCi/L	5.3 km (3.3 miles)

Road and Bethel Church Road conveniently define the east and west boundaries, respectively, of the potential area impacted by the PGDP groundwater contamination. This larger area map (1:12,000 scale) addresses approximately 5950 hectares (14,700 acres) of the DOE reservation and other lands between the plant and the Ohio River. Each map represents contaminant levels observed in or inferred from RGA monitoring wells during CY 2000, plus data from temporary characterization borings. These maps are composites of three sets of working maps of the lower, middle, and upper RGA [elevations 76.2 to 89.9 m (250 to 295 ft), 89.9 to 93.0 m (295 to 305 ft), and 93.0 to 97.5 m (305 to 320 ft) amsl]. Letter-size versions of the working maps are included in Appendix A. Additional discussion of how the maps were developed is presented in Appendix B. The data set and trend plots for key wells used in the interpretation also are included in Appendix B. Figures 3 **(not shown in this report)** and 4 **(not shown in this report)** show the locations of wells and facilities referenced in the text. Figure 5 **(not shown in this report)** shows the areas of SWMUs and WAGs identified in the text.

4. SIGNIFICANT REVISIONS TO PREVIOUS PLUME MAPS

This year's (CY 2000) plume maps incorporate several revisions from the plume maps for CY 1999. These revisions reflect the following: 1) the incorporation of the WAG 3 RI data (DOE 2000d), a significant data set of groundwater quality for the west side of the plant, 2) changing water quality as documented by the continuing monitoring well program, and 3) reinterpretation of spatial trends. The following highlights the most significant revisions to the previous plume maps.

- Redefinition of spatial trends in the Southwest Plume (WAG 3)
  - Addition of WAG 3 RI data supported a reassessment of contaminant levels in the Solid Waste Management Unit (SWMU) 4 area.

- C-746-C area reinterpreted
  - High contaminant levels in the RGA attributed to branch off of the Northwest Plume.
  - Separate source area no longer required for C-746-C.
  - Plume migrates to C-746-S&T Landfill area.

The main revisions to the groundwater plume maps and contaminant trends for each plume are described in the following subsections.

4.1 NORTHEAST PLUME

4.1.1 Trichloroethene

Within the Northeast Plume, contaminant levels above 5 mg/L cover a large area as a result of several potential source areas. The highest concentrations (as high as 1100 mg/L in MW288–near the Northeast Plume well field) are found in a narrow core along the eastern edge of the plume. The most upgradient source area for this high concentration area appears to be near the northwest corner of the C-333 Process Building. An additional source area contributing to the high concentration area appears to be in the vicinity of the C-340 Metals Reduction Facility (1400 mg/L detected). Nevertheless, the source to the main plume centroid of the Northeast Plume remains undefined. Other areas that appear to be contributing to the Northeast Plume include the northeast corner of the C-400 Building and the C-410 Building. TCE concentrations of 1700 mg/L were measured immediately northeast of the C-400 Building during the WAG 6 RI (DOE 1999a). Further east, samples collected from MW260 contained TCE levels between 560 and 620 mg/L during CY 2000.

Trichloroethene levels in some of the monitoring wells associated with the main high concentration area near and within the plant boundaries have continued to decline through CY 2000. In 1995, samples from MW258, located immediately east of the C-755 Subcontractor Staging Area, had initial TCE concentrations above 2300 mg/L. The most recent samples collected from this well (November 2000) contained only 880 mg/L (down from 1100 mg/L in November 1999). This trend of declining TCE levels near the plant suggests that dissolution may be rapidly depleting the DNAPL source zones to the Northeast Plume.

Moreover, TCE levels in the main core of the Northeast Plume outside the plant boundaries have declined significantly. Values for the downgradient Northeast Plume well field monitoring wells MW293 and MW294 dwindled from 1150 and 1350 mg/L for CY 1999 to 225 and 470 mg/L, respectively, for CY 2000. For the same period, TCE levels for upgradient Northeast Plume well field monitoring well MW292 dropped from 1100 to 860 mg/L. The declining TCE levels downgradient of the Northeast Plume well field indicate that the pump-and-treat system is being effective at containing the core of the off-site plume.

4.1.2 Technetium-99

Contaminant levels are generally less than 25 pCi/L offsite and are only greater than 100 pCi/L at a few discrete sources. The most upgradient source area appears to be the northwest corner of the C-333 Process Building. Lesser source areas downgradient of C-333 are the C-340 Building and a classified materials storage area located on the foundation of the former Kellogg Building (now SWMU 99). The elevated ^{99}Tc activity in lower RGA well MW256 (consistently near 80 pCi/L through CY 1999 and CY 2000) is attributed to a Kellogg Building area source.

Both the C-410 Building and the northeast corner of the C-400 Building appear to be source areas of discrete centroids of ^{99}Tc contamination moving to the east within the broad boundaries of the Northeast Plume. Technetium-99 activity is interpreted to be greater than 100 pCi/L beneath the C-410 Building. Groundwater analyses of the WAG 6 RI showed that ^{99}Tc activity in the upper RGA beneath the northeast corner of the C-400 Building was greater than 900 pCi/L.

4.2 NORTHWEST PLUME

A primary revision of the CY 2000 plume maps is the depiction of an alternative source of RGA dissolved contaminants for the C-746-C area. The CY 1999 plume maps and report attributed elevated levels of both TCE and ^{99}Tc to a previously undefined C-746-C (scrap yard) area source. This year's assessment of the groundwater plumes suggests another interpretation–that contaminants may be derived from the Northwest Plume. The available data are consistent with either interpretation of the source of the C-746-C area contamination in the RGA.

The primary evidence for a Northwest Plume origin of the C-746-C area contamination is 1) the presence of TCE and ^{99}Tc (both common to the Northwest Plume) and 2) the vertical trend of contaminants within the RGA. Levels of both contaminants are highest in the middle and lower RGA, as in the Northwest Plume. In general, contaminant levels beneath a shallow source area are expected to be highest in the upper RGA.

In this year's interpretation, leakage from the C-616 Lagoons is causing a mound of higher hydraulic potential beneath the lagoons. Thus, the general northward groundwater flow diverges to the east and west. This east plume branch is projected to extend northward to the C-746-S&T Landfill area.

Analyses of groundwater samples collected during the Sitewide Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination (DOE 2000b) provide the only data on contaminant levels in the plume branch in the C-746-C area. The maximum TCE concentration measured in the core of this plume branch was 2200 mg/L (soil boring DG-007) in the middle of the RGA. Concentrations in excess of 100 mg/L are interpreted to extend to near the C-746-S&T Landfill. Technetium-99 activity exceeds 900 pCi/L in the core of the off-site plume branch. The extent of the off-site ^{99}Tc plume, as defined by an activity of 25 pCi/L, is primarily limited to the area south of the C-746-S&T Landfill.

4.2.1 Trichloroethene

Compared to the Northeast Plume, TCE contamination in the Northwest Plume covers a smaller geographic area. However, the TCE concentrations in the core of the Northwest Plume are higher than the TCE concentrations in the Northeast Plume. Outside the security fence, TCE concentrations measured in the core of the Northwest Plume during CY 2000 were as high as 7800 mg/L (MW248), as compared to the maximum concentration seen in the Northeast Plume, 1100 mg/L. Immediately downgradient of the north extraction well field, measured TCE

concentrations during CY 2000 were as high as 1500 mg/L (MW236). Monitoring well data for the South Well Field continue to show capture of the TCE core of the Northwest Plume. The CY 2000 maps reflect a growing break (based on a conceptual model only) in the Northwest Plume at the South Well Field.

A possible TCE source area upgradient of the C-400 Building was identified in the vicinity of the C-310 Product Building during the WAG 28 RI (DOE 2000a). Alternate interpretations of this area are possible, which may include the TCE being associated with either the Northeast Plume or Southwest Plume contamination areas. Regardless of the direction that the TCE from the C-310 area may be migrating, the TCE sources at the southeast corner of the C-400 Building remain the primary probable sources for the Northwest Plume.

The detection of TCE in surface-water samples from a discrete area of Little Bayou Creek near the Shawnee Steam Plant (5 to 30 mg/L TCE during CY 2000) defines a discharge area of the Northwest Plume. Consequently, the middle and lower RGA TCE plume maps show the plume terminating at Little Bayou Creek, with the exception of an eastern finger that is coincident with the Technetium-99 Plume. The spreading of the plume near its northern end reflects 1) trends in monitoring results for the area and 2) frequent change of groundwater flow directions in the area in response to changes in the Ohio River stage.

4.2.2 Technetium-99

The Northwest Plume includes a ^{99}Tc activity near 900 pCi/L at the north well field and near 3790 pCi/L at the south well field. A core of contaminated groundwater with greater than 100 pCi/L ^{99}Tc activity extends to Little Bayou Creek, where the groundwater discharges to the creek (detected 9 to 37 pCi/L ^{99}Tc during CY 2000). The CY 2000 monitoring well data support the mapping of a "clean" area between the north reaches of the Northwest and Technetium-99 Plumes.

Groundwater data of the WAG 6 RI indicate an upgradient source of ^{99}Tc near the southeast corner of the C-400 Cleaning Building. However, the primary source of ^{99}Tc remains in the northwest corner of the C-400 Building and the adjacent reach of the North-South Diversion Ditch (10,000 to 40,000 pCi/L in the basal RGA).

4.3 SOUTHWEST PLUME

4.3.1 Trichloroethene

Groundwater sampling conducted as part of the WAG 27 RI (DOE 1999b) confirmed the existence of the Southwest Plume. Additional sampling during the Sitewide Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination (DOE 2000b) and the WAG 3 RI provided detail of the plume's structure and identified a previously unknown source of groundwater contamination at SWMU 4. The maximum measured TCE concentration onsite was 67,000 mg/L in boring 004-027, located immediately west of SWMU 4. Outside the plant fence, the maximum measured TCE concentration was 480 mg/L in boring DG-016.

Like the Northeast Plume, the Southwest Plume appears to collect TCE from multiple sources including the C-720 area, the Oil Landfarm (SWMU 1), and the Cylinder Drop Test Site (SWMU 91), with the major source being SWMU 4. Other potential source areas include the C-310 Building and the southwest corner of C-400.

4.3.2 Technetium-99

The WAG 3 and 27 RIs (DOE 2000d and 1999b) and the Sitewide Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination (DOE 2000b) provide the primary data used to define the extent of contamination in the Southwest Plume. Highest levels (3710 pCi/L, taken from temporary boring 001-182 in the lower RGA) are derived from the burial ground area of SWMU 4. Lesser discrete upgradient sources are found to the east at the C-310 Building, the northeast corner of the C-720 Building, and the north side of the C-409 Building. The off-site plume of $\geq$ 900 pCi/L is restricted to within approximately 91 m (300 ft) of the PGDP security fence line. Technetium-99 activity of $\geq$ 25 pCi/L extends to New Water Line Road on the west side of the plant. Groundwater flow directions, as inferred from RGA hydraulic potential maps, indicate that the contamination will migrate northward, potentially

merging with the Northwest Plume near the Northwest Plume south extraction well field.

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Technetium-99

Only limited data are available to define the source and extent of the Technetium-99 Plume. The plume source, which is generating at least several hundred pCi/L of ^{99}Tc in the nearby RGA, appears to be located in the area of the northwest end of the C-616-E Lagoon. The Technetium-99 Plume passes under the northwest corner of the C-746-U Landfill, where MW275 intercepted water with a maximum ^{99}Tc activity of 213 pCi/L during CY 2000. The PGDP's North-South Diversion Ditch is a potential alternative source of the ^{99}Tc activity observed in the MW275 area. Groundwater analyses of MW152 document up to 219 pCi/L of ^{99}Tc in the RGA during CY 2000 (attributed to the Technetium-99 Plume) near the Shawnee Steam Plant.

These maps project the plume to extend to the Shawnee Steam Plant water intake canal, off the Ohio River, where both the PGDP and Shawnee Steam Plant derive their plant process water (a collective withdrawal of 10 to 20 million gal of water per day). The primary lines of evidence that the Technetium-99 Plume extends to the water intake canal are as follows:

1) a continuing presence of 150 to 350 pCi/L ^{99}Tc in water samples from MW152, located 2200 ft from the canal, since monitoring began in late 1993;

2) hydraulic potential gradients that indicate groundwater (with contaminants) flows from the MW152 area to the canal; and

3) a conceptual model of the RGA flow system in which the canal is the focus of discharge of groundwater because of the large surface water withdrawals from the canal and because the canal forms a bypass whereby groundwater discharges short of the main Ohio River channel.

Water samples from the intake canal have not contained detectable levels of ^{99}Tc contamination. This may be attributed to a high rate of dilution of groundwater discharge with Ohio River water in the canal.

5. TRENDS AT THE PGDP PUMP-AND-TREAT FACILITIES

Monitoring well systems located at the Northeast Plume Containment System and at both well fields of the Northwest Plume Groundwater System provide a means to assess the effectiveness of the interim remedial actions. The following sections summarize the interpretation of trends of groundwater contamination within the well fields over the life of the operations. Pumping has been ongoing in the Northwest Plume well fields since 1995. Operation of the Northeast Plume well field began in 1996. Generally, only minor changes in conditions at the extraction fields have been noted over the past year. These changes have been related both to variations in the concentration of contaminants within the RGA groundwater migrating past the well fields and to the expanding capture radius of the extraction wells.

5.1 NORTHEAST PLUME CONTAINMENT SYSTEM

5.1.1 TRICHLOROETHENE

Contaminant trends for the monitoring wells associated with the Northeast Plume Containment System show that TCE levels have decreased significantly since installation of the extraction wells in 1996. During the past year, the maximum concentration of TCE downgradient of the extraction field (as documented in MW294) has decreased by nearly 50% (from 810 to 420 mg/L). This decline follows the general downward trend of the concentration of TCE in groundwater observed upgradient of the well field at MW292 (1400 to 880 mg/L since mid 1999).

5.1.2 Technetium-99

During CY 2000, all analyses of groundwater from the Northeast Plume facility are less than the 25 pCi/L action limit for ^{99}Tc.

5.2 NORTHWEST PLUME CONTAINMENT SYSTEM

5.2.1 Trichloroethene

South Well Field

Trichloroethene concentrations in the downgradient monitoring wells of the South Well Field clearly show that the high concentration TCE core is being captured by the two extraction wells. Since 1996 the maximum concentration of TCE at the monitoring wells located at the South Field has fallen steadily from greater than 16,000 mg/L originally to less than 2000 mg/L during June of 2000. This decrease in the TCE concentration was achieved, even though the TCE concentration of groundwater migrating into the well field has risen steadily.

North Well Field

Although the concentration of TCE observed at upgradient MW234 has remained similar to last year's level, most of the monitoring wells adjacent to the extraction wells have shown a decrease in TCE levels during CY 2000. However, during the same time period, downgradient MW236 has shown steady increases in TCE concentrations (from 1200 to over 1500 mg/L). This suggests that the North Well Field is effectively removing TCE in the area immediately surrounding the extraction wells, but that the core of the plume may be moving past the capture zone of the North Field along the east side.

5.2.2 Technetium-99

South Well Field

Groundwater analyses for monitoring wells of the South Well Field demonstrate that the extraction wells are effective in the capture of the ^{99}Tc plume core. In general, although groundwater containing increased levels of ^{99}Tc has been observed upgradient of the well field, the activity of ^{99}Tc has fallen steadily in the monitoring wells located adjacent to the extraction wells and at downgradient MW243 (from 1060 pCi/L in CY 1999 to 169 pCi/L in CY 2000). On the east side of the extraction field, consistent ^{99}Tc activities in MW242 (between 130 and 180 pCi/L during CY 1999 and 2000) indicate that some ^{99}Tc contaminated groundwater is migrating past the well field along the east margin of the plume.

North Well Field

Technetium-99 analyses for the North Well Field suggest that the extraction wells (particularly EW229) have remained effective in capturing the core of the ^{99}Tc plume. Technetium-99 levels in monitoring wells on the west side of the well field continue a trend begun in 1995 of decreasing ^{99}Tc activity (between 130 and 180 pCi/L during CY 1999 and 2000). However, recent analyses continue to show a higher ^{99}Tc activity on the east side of the well field (1100 to 1800 pCi/L in MW234). This trend indicates that some migration of contaminated groundwater is occurring past the North Well Field along the east margin of the plume.

6. USES OF THIS REPORT

This evaluation of groundwater contaminant trends for CY 2000 supports several goals of the PGDP environmental program. Foremost, the updated plume maps and definition of trends will be used in remedial action decisions for the Groundwater Operable Unit to provide the following information:

- define additional areas contributing significant contamination to the RGA,
- scope the dimensions of potential remedial actions, and
- refine the extent of off-site areas that will be addressed by temporary or permanent institutional controls.

This same assessment will support the ongoing evaluation of the adequacy of DOE's Water Policy and effectiveness of the PGDP groundwater monitoring program. To this end, this report is being included as an appendix to the 2000 Annual Site Environmental Report. In addition, the trends and extent of contamination defined by this report will

help identify areas of groundwater/surface water interaction to be considered in the upcoming RI of the Surface Water Operable Unit.

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